

THE TEACHING OF
Rural Science
IN TROPICAL
PRIMARY SCHOOLS

By I. P. SHANKS

OXFORD UNIVERSITY PRESS

An understanding of Science is vital not only to expert scientists but to ordinary men and women. It is as necessary for them to know what scientists try to do and how they try to do it as to be familiar with scientific facts and principles.

This series of books, of which particulars are given on the back of the wrapper, has been designed to advise and help teachers of Science, particularly those working in the rapidly developing tropical countries, to give their pupils this understanding through a view of science as a whole.

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IN TROPICAL
PRIMARY SCHOOLS

I. P. SHANKS

Being VOLUME II *of the*
UNESCO HANDBOOKS
ON THE TEACHING OF SCIENCE
IN TROPICAL COUNTRIES

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General Introduction

This is a book for teachers, teacher-educators, and teachers-in-training, whether they be concerned to improve their work through their own initiative or participating in full-time or part-time training courses. Moreover it has material which is relevant to the middle school as well as the primary school, and although reference is made to a tropical background when considering some details of class-work, the general principles of education and science presented have application and value in all countries. In this age some understanding and application of science must become an integral part of man's everyday life and thought, most beneficially to be achieved through an education which brings the spirit as well as the practices of science to the classroom whilst interrelating science and the other parts of the curriculum. To facilitate this approach to science in education, this series of Unesco Handbooks was devised. The present book, Volume II in the Series, is the seventh to be published and follows:

- I THE TEACHING OF SCIENCE IN TROPICAL PRIMARY SCHOOLS
 - V THE TEACHING OF ARITHMETIC IN TROPICAL PRIMARY SCHOOLS
 - VII THE TEACHING OF GENERAL SCIENCE IN TROPICAL SECONDARY SCHOOLS
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- III THE TEACHING OF HEALTH SCIENCE IN TROPICAL PRIMARY SCHOOLS
 - IV THE TEACHING OF HOME SCIENCE IN TROPICAL PRIMARY SCHOOLS
 - VI THE TRAINING OF PRIMARY SCHOOL SCIENCE TEACHERS

The Series originated in the need, frequently expressed to the United Nations Educational, Scientific and Cultural Organization, for help in the development of science teaching which meets today's

purposes and methods in schools and which will contribute to the promotion of better health and life, industry and agriculture. In response to this appeal UNESCO conceived the plan and the method of presentation of the series and agreed to subsidize the preparation of the ten manuscripts. Responsibility for choosing the authors and the general editor and for the cost of publication was undertaken by the Oxford University Press in agreement with UNESCO.

Officers in the Curricula and Methods Division, Department of School and Higher Education of UNESCO, who read the draft of this book, made comments and suggestions which were most helpful in the final stages, without reducing the responsibility of the author and editor for what is now presented.

JACK WILSON

Preface to Volume II

Part One (Chapters 1-3) of this book outlines the scope of rural science as a primary school subject in tropical lands, bearing in mind the two important factors that (a) the development of agriculture is vital but only just beginning to benefit from modern practice and equipment, and that (b) formal education of many of the pupils in these lands may not extend beyond their primary years. Part Two (Chapters 4-6) covers, in considerable detail, suggested methods of bringing out the 'Main Ideas' of the topics which have been included in a possible six-year scheme according to the particular age groups.

It will be noticed that this arrangement of material is similar to that in Volume I of the series, *The Teaching of Science in Tropical Primary Schools*. This has been planned intentionally: rural science lessons are concerned with those principles of science which can be brought out through observational and experimental work in a garden, and through certain farm studies and the care of small livestock. To appreciate fully the meaning of rural science, lessons such as are proposed here must be supplemented by others concerned with the elements of general science and nature study, such as are dealt with in Volume I. It is hoped that teachers in schools in rural areas of tropical countries will plan their schemes of work with this in mind, and will adopt a wide interpretation of science as a primary school subject, putting the accent on whichever topics are most relevant to their locality.

Rural science topics have educational importance for all, however, and teachers in schools in urban areas should not forget that an understanding of land use, and a knowledge of countryside pursuits and garden work, can have a beneficial influence on children in their schools, just as well as on those in rural areas.

This book is not a text on gardening and agriculture. It is concerned with teaching methods at the primary level; it is intended to help the teacher who asks, 'How can I use the school grounds, and the farms amongst which we live, and the activities of human beings in rural areas in general, to help my pupils gain an understanding of what rural science is about, and how it may be applied for the benefit of man?'

I. P. SHANKS

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PART ONE

CHAPTER I

The Scope of Rural Science

SCIENCE IN EDUCATION

As mankind gradually comes to accept greater responsibility for the control of his environment, science subjects in schools are sure to increase in importance everywhere and at all stages of education. In tropical lands the traditional ways of life have sometimes been based on unscientific customs and habits; and methods of education have been generally authoritative, concerned to tell the pupils what to think and believe, not to encourage them to find things out for themselves, and with the accent on the need to satisfy literacy before all else. In these regions of the earth's surface in particular, a more widespread appreciation is urgently required of the scientific knowledge that is now available, and of the hopeful possibilities which science offers for the future. The great need is for a unified view of the various aspects of science and their application; of the basic ideas fundamental to all science concerning the form and behaviour of matter itself; of the phenomena concerned with the structure of the earth and its place in the universe, the weather and the soil, and the study of living things which inhabit it; and of the problems particular to man, such as the ways in which he is able to use his scientific knowledge to improve his physical environment and maintain his health and welfare generally. In this last respect, not least in importance are the applications of science concerned with the production of food. In comparatively recent years, man has begun to realize that his social problems, also, can only be solved satisfactorily through a scientific approach. And the social problems of today, it must be realized, are immense. Perhaps the greatest of these facing the nations of the world now is the manner in which the increases in population everywhere are outstripping living space and food supplies. There is much confused thinking on problems of this kind, partly because of ignorance; and it is certain that not until people have come to accept the fact fearlessly that they have only themselves to rely on, that only by

investigating the problems, taking thought, and trying out alternative possibilities in a manner as scientific as possible, will there be any hope of a solution to such matters. There is also a need for an increased trust in the knowledge man is accumulating through this scientific method which he has developed. Although superstition is still widespread in the world, it is true to say that there are more scientific ideas prevailing amongst people nowadays than ever before in history. There is further encouragement in the realization that these ideas have spread throughout the world, irrespective of geographical or political boundaries, races or creeds, and have brought immense benefit everywhere.

Science has a further importance in education. Science puts the spirit of inquiry foremost, and this is also the essence of good teaching. It has become clear that science is a way of finding out about things, as well as being a collection of facts, and teachers must appreciate this if their work is to be truly effective. To teach the facts of science, even to teach the ideas of science which follow an understanding of the facts, without giving the pupils the opportunity to make discoveries and investigate problems themselves, however simple, is to lose half the value of this approach to learning. And this gives importance to the practical aspects of science teaching, such as we will be concerned with in this book: it should be a teacher's first aim to put his pupils into situations wherein they can actively find things out for themselves. This would be to encourage right methods of learning, not only in the so-called 'science subjects', but in all school work. This approach to learning may be summed up in the phrase 'the scientific attitude'—the attitude which appreciates the value of forming ideas based on observations and reliably tested information, that realizes the significance of the changing nature of knowledge and understanding, and is content to say 'I do not know' until the evidence is sufficient to answer the problems. How to bring about such an attitude amongst the peoples of the world is fundamentally an educational problem. It is, therefore, no use having one approach for small children and another for older pupils: our methods must be unified. A scientific education in this sense must begin as early as possible in our schools, and continue through all the stages.

RURAL SCIENCE IN TROPICAL LANDS

To spread scientific ideas, to give opportunity for active learning, and to encourage the scientific attitude: these then are our three main

objectives as teachers of science. Rural science as a school subject is fundamentally an approach to learning through the principles underlying garden work, farming activities, and other rural occupations, and it may be seen that it is a particularly valuable subject for incorporating these overall aims.

In tropical lands the occupations of the people are generally related to agriculture; and some knowledge of the contribution that applied science is making towards improving the cultivation of food crops and other plants, the care and conservation of the soil in which they grow, and the management of domesticated livestock, will be of value to all pupils, whether they eventually find their life's work in occupations directly concerned with agriculture or not. The teaching of rural science will include many of the scientific ideas behind such useful knowledge, and if handled sympathetically from a broad point of view, will prepare the way towards an intelligent understanding of science in general.

Rural is a word meaning 'of the country' (in contrast to *urban*, which means 'of the town'), and because tropical lands in general are not yet industrialized in an urban fashion, school surroundings generally have this rural character. This is fortunate, because the environment, inevitably, has an important influence on a developing personality; and a natural environment, if used to the best advantage by a good teacher, will provide a wealth of experience which will last a lifetime. The child is in contact with his surroundings directly, through the senses, and because of this rural science has an advantage over most other subjects: it deals wholly with concrete material. Being, moreover, very much a practical subject, it is well suited to provide occasions for pupils to learn through their own activities in real situations, which is as sound a basis for education as one could desire.

RURAL SCIENCE AND CHILDREN'S INTERESTS

Man is different from all other forms of life, not only in his earnest seeking to find out about the world around him, but also in his ability to reflect on what he discovers. He uses these reflections as the basis of further investigations; and he has also developed the unique ability of being able to apply his knowledge in ways which make his life more satisfactory and complete, ways which make possible greater fulfilment.

Children in all lands and at all ages demonstrate this natural

inquisitiveness, not only about the world in which they live but also about what people older than themselves are doing in it. As well as seeking knowledge of the physical world itself, children like to see things grow and develop, and young creatures and other small forms of life have great fascination for them. Yet even in an agricultural environment where such experiences are common (perhaps, indeed, just because they are so familiar to children), their true value needs to be taught as objects which will repay careful study. The commonplace is too often taken for granted. This, then, gives further meaning to rural science as a school subject: its content is naturally interesting to children, yet a proper understanding of it requires careful encouragement and guidance from the earliest years.

THE CONTENT OF RURAL SCIENCE

In a rural environment, the variety and quantity of material available for study is vast, and may be overwhelming in its detail. The teacher, therefore, has an important function to perform in selecting that which is relevant to his pupils at any particular age. What selection of lesson material, then, should be included in a syllabus of rural science which is to be part of a general pre-secondary education for tropical schools?

Although it will be necessary to include practical as well as theoretical aspects of the subject (and some knowledge of manual skills will also be required), teachers should not be so much concerned with giving instruction on how to farm or garden, as with using examples from these occupations to accentuate scientific ideas. To put it another way, the approach should be educational, not vocational: by using scientific ideas, however simple, a teacher can make clear why certain agricultural and gardening activities are more desirable than others.

Basic to the whole subject is a knowledge of the soil and the important part it plays in the lives of men, and indeed, of all living things. There is probably no more important single topic in all education than the connexion which exists between soil and life in general; teachers should be well aware of its fundamental significance. All over the world there is evidence that people are not being educated sufficiently in this respect. Whilst populations increase at a rate which condemns millions to near-starvation, the soil continues to be used up in a reckless and irresponsible manner.

The study of plant life divides itself into three main sections:

garden plants, food plants (whether for livestock or for human consumption), and other farm crops (such as the special cash crops grown in most localities). In each of these sections, as well as the recognition of the various plants and their general principles of growth, ideas behind propagation methods, cultivation, harvesting, and the protection of the crops against pests and diseases, will all provide material for lessons.

Children should learn that there are different kinds of farms, and understand something of the variety of farming activities in different parts of the world. The design, construction and use of the buildings and equipment which farming necessitates may also provide topics for interesting lessons. An idea of the position occupied by agriculture in a country's economy, including agricultural exports, could be the means of introducing pupils to a more advanced study of agriculture in later school years.

Some study of farm animals should not be omitted, and the practical work will include keeping small livestock as pets. On farmland, and in the garden, many wild plants and animals will be encountered, and there will be numerous occasions when their inter-relationship with domesticated plants and animals may be studied.

Although there are a few topics which are only appropriate to older pupils, it should be appreciated that most may be taught at any level in school. But it is important that teachers realize that their approach must be different, according to the age of the pupil. This point is considered in greater detail in Chapter 3.

LINKS WITH OTHER SUBJECTS

In spite of the emphasis on 'subjects' in most tropical schools at present, at the primary level of education there should be the minimum of division between one aspect of knowledge and another. Subjects are artificial divisions, after all, more convenient to the teacher than to the pupil; and in fact, it is always found that topics in one subject inevitably overlap those in another. If, however, rural science is included in the curriculum, it will prove to be a most suitable 'unifying' subject, as it has links with many practical activities and aspects of knowledge. In the sections which follow, an attempt has been made to suggest a few of the most obvious correlations with topics and ideas usually included as the content of subjects other than rural science.

Science and nature study. There is a more obvious link with these

subjects than with any others. It has already been stressed that a basic knowledge of the science of both living and non-living things is essential to a proper understanding of rural science (see Preface). In fact, from one point of view, it might be said that the main aim of this book is to indicate the way in which the scientific ideas related to the proper use of rural land can be made meaningful to the child. But there is another approach which might be adopted: in science and nature study lessons, examples from topics normally included in the syllabus for rural science can be used to illustrate the ideas concerned. Suggestions are given in the table below on how this might be done.

<i>Science and Nature Study Topics</i>	<i>Rural Science Topics</i>
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<i>Simple chemistry of matter</i>	Soil structure and fertility Fertilizers Foodstuffs and feeding systems Milk, cream and cheese Insecticides and fungicides
<i>Weight</i>	Crop yields Growth rates of livestock Comparison of soils
<i>Work, energy, machines, etc.</i>	Garden tools Farm implements Food values Dairy equipment Building structures Water pumps Grain mill
<i>Temperature</i>	Animal health Crops and altitude Composting Grass preservation Germination Seasonal changes
<i>Air and water</i>	Soil cultivation Mulching Plant growth Ventilation of buildings Water supply
<i>Atmosphere and the weather</i>	Seasons and planting times Aspect in relation to site Length of growing times Effect of sunlight on crops Sunlight and livestock

<i>Rocks and the soil</i>	Soil studies Depth of top-soil Sub-soil and drainage Soil fertility Humus and the top-soil Effect of underlying rock strata
<i>Classification of living things</i>	Plant families Trees, shrubs and herbs Types of domesticated stock Breeds of livestock Animal parasites Plant pests
<i>Evolution and natural history</i>	Animal breeding Development of garden plants
<i>Food and Digestion</i>	Comparison of process in farm livestock Comparison of food requirements Stall feeding of cattle Food values of crops Livestock produce
<i>Reproduction</i>	Care of small livestock Seed sowing Vegetative propagation Conditions for germination
<i>Animal studies</i>	Wild birds and the land Useful animals in a garden Bee-keeping Farm and garden pests
<i>Non-flowering plants</i>	Fungus diseases Ferns as decorative plants Bacteria in compost, etc.
<i>Plant studies</i>	Timber plants Oil-bearing plants Beverages Fibre crops Other useful plants Grassland management
<i>Plant and animal communities</i>	Farming systems Agricultural land use

Mathematics. If it were not for the importance given to this subject in examinations, and the consequent need to practise examples which are often unreal, mathematics could be made a subject of great practical application, as the opportunities for calculation and measurement in real situations are innumerable. The particular advantage of using examples from rural life in mathematics is that they are likely

to be related to the pupils' own experiences, and therefore of interest to them. Subjects benefit by having local relevance wherever possible.

In order to decide whether any particular farming activity is profitable or not, a farmer must keep accounts; and these, in turn, will need to be based on costings, which are calculations made to discover how much it has cost to produce an article. For example, successful dairy farming results from the accurate recording of milk yields; the value of fertilizers and manures is indicated by the quality and quantity of the produce obtained from the fields after harvesting; the quality of a bull is tested by recording the performance of the offspring. Such calculations are the means by which decisions about much farm work are made possible; and they all rely on a knowledge of simple mathematical processes. Examples of this kind will give the opportunity for arithmetical practice in rural science lessons in schools.

In the garden also, there will be many chances to practise simple calculations: quantities of seed to sow; spacings of crops; amounts of manures; crop yields; calculations related to fencing and hedging work; the layout of paths and drains; terrace construction. These are but a few of the possible situations in which mathematics can be introduced into gardening activities.

Health education and housecraft. The only really effective way to teach health science is to make it possible for the children to live healthily: many theoretical lessons in this subject at primary level have little value. The maintenance of the school and its grounds in a clean condition will be part of this training. This will include the composting of all waste matter from the school grounds; and in ways such as this, there can be correlation with rural science. There is another topic, however, which ought to be included in a health education syllabus, and which can be made more meaningful if linked to the rural science work connected with the care of small livestock: this is sex education. The earlier children are encouraged to have an open, sensible, and accurately-informed attitude to sex matters, the better. No age is too young for this teaching, though again, the approach will be different at each stage. With young children, no formal lessons will be required; their questions will be waited for and then answered seriously and honestly. It is here, particularly, that the care of livestock is a useful aid, for how better can first ideas about the sex relations between male and female be introduced, than from the starting point of the mating of domesticated animals which are known to the children and loved as pets?

It is fitting that those who are to cook the food for the family should know something of how it is produced. In this respect, there is every reason why girls in school should take part in gardening and agricultural activities, as well as study housecraft. But there is no reason why boys should not also learn something about the cooking of the food they are being taught to produce. Such an approach to curriculum planning is much to be desired in the modern world, where men and women are taking an equal part in everyday affairs as well as in the home. The school curriculum for all, therefore, should include the production of food, the composition of foodstuffs, the working of the human digestive system, something about nutrition and the composition of a healthy diet, as well as how to prepare the food and make it palatable.

Geography. The idea of using the school grounds as an introduction to the wider problem of land use should be uppermost in the teacher's mind. There will be numerous opportunities for the study of local crops and livestock in their geographical setting. The dependence of farming activities on such factors as the weather, prevailing winds, and the altitude, needs to be understood.

Maps are allied to plans, and in making a simple survey of a school garden, children will be introduced to the elements of map-work, which is the basis of all geographical studies.

The soil itself is the raw material of gardening, and is therefore a factor common to rural science and geography, for the changes in soil which occur from place to place will depend largely on the underlying rocks; and, of course, these are the true foundation of geography in a very real sense.

The economic aspects of geography must not be forgotten; and it is in this respect that there is a most important correlation. The green plant is the only means by which the energy in sunlight is transformed into foodstuffs and other raw materials used by man; and the distribution of such plants as can be put into the service of man is the basis of a farmer's choice of the crops which he can grow in any particular area. Man, therefore, as an agriculturalist, has come to influence the distribution of plants; whilst at the same time the geographical conditions which control the natural plant cover of the earth's surface, affect the distribution of man.

In less direct ways, too, geography can be linked to rural science. Many plants which can be grown in a school garden will not be native to the locality in which the school is situated, but will have been introduced, in some instances, from overseas. An enthusiastic

teacher will make every effort to discover from where his plants have originated; and one way of doing this is to scrutinize the botanical name of the plants, particularly the specific name. The following are a few examples to illustrate the point. *Cereus peruvianus* (a cactus from Peru), *Ficus bengalensis* (a tree from Bengal), *Phoenix canariensis* (the Canary Island palm), and *Buddleia madagascariensis* (a shrub from Madagascar).

A broad-minded teacher is continually on the look-out for opportunities to make use of lesson material which will prepare his pupils for international understanding and a co-operative world, and geographical ideas can do much to help give such a world view. It is part of the educational process to grow out of the limited 'clannish' attitudes in which we so often begin our lives; even out of national ones, eventually. Though this process may seem to be rarely completed, there are nevertheless more people in the world today than ever before who have an international point of view. Something can be done by teachers with such an attitude themselves, to counteract the narrower viewpoint, by relating what geographical knowledge they have to each of the subjects with which they are concerned.

History. Gardening began many thousands of years ago when the peoples of ancient Egypt first realized that the decorative effect of careful planting was pleasurable, and that trees could be sited to give shade where it was most needed, whilst also producing timber for the use of craftsmen. Throughout the ages since then, gardens have played an important part in the civilizations which have flourished all over the world. There have been the formal enclosed gardens of Persia, and later of France; the naturalistic landscaped gardens of Britain; and the colourful and florally attractive parks and garden layouts of modern cities everywhere. Some knowledge of this history of decorative gardening should be part of the education of all, in every land.

With the aid of an encyclopaedia, teachers can acquire much interesting background knowledge about botanical science and the history of its development, by referring to the names of persons who first collected or identified plants. This can be followed up by interesting lesson work on the lives of the people concerned: such plants as *Berberis Darwinii*, *Hypericum Hookerianum* and *Grevillea Banksii* indicate what is meant.

The occasion when plants were first brought into cultivation is another interesting idea to follow up. The ancestry of the grape vine goes back thousands of years; a wild wheat plant was the first known

grass to be cultivated as long as seven thousand years ago; the rose is so old that its ancestry is unknown. A teacher will come across references to many plants in the course of his general reading, and he can use the information he acquires to give historical meaning to rural science work generally.

An outline of the development of world agriculture should be included as an important aspect of history teaching in schools, because the methods of agriculture used everywhere today, and those certain to be used in the future, nevertheless have their origins in the distant past. The following are approximate dates when important crops, animals, and agricultural methods and ideas were first introduced.

- 6000 BC The first harvesting of wild grasses in Syria, Palestine and Asia Minor. The use of the flint sickle for reaping.
- 5000 BC First cultivation of wild grasses in Egypt; the first recorded domestication of cattle, pigs and goats.
- 4000 BC Metals first used as tools. The olive plant first cultivated in the Nile delta.
- 3000 BC The wheel. The ass domesticated in Mesopotamia. Irrigation agriculture in the Indus valley. Poultry domesticated. Cotton grown in Peru, and rice in China.
- 2000 BC Horses used on farms in Britain. Simple wooden ploughs in use in Greece. Maize under cultivation in North America.
- 1000 BC The cultivation of wheat in NW Europe. Sugar cane grown in the South Pacific.
- 500 BC The invention of the heavy plough in NW Europe.
- 1 AD The ox-plough first used in Britain.
- 400 AD The open-field system of farming in NW Europe.
- 700 AD Sugar cane introduced into the Mediterranean region.
- 1500 AD The beginning of the enclosures in Britain. Rubber being collected in Brazil.
- 1700 AD Selection of livestock for breeding purposes in Britain.
- 1750 AD Development of improved rotations in Britain.
- 1800 AD Modern breeds of cattle established in Britain. Rubber plantations established in Ceylon and Malaya.
- 1840 AD Fertilizers first used in Britain. Start of co-operative markets in Denmark.
- 1880 AD Cocoa plantations established in West Africa.
- 1900 AD Sisal and coffee planted in East Africa. Completion of the enclosures in Britain.
- 1920 AD Wheat, tea and European breeds of livestock introduced to East and Central Africa.
- 1940 AD Revival of alternate husbandry in Britain.
- 1950 AD Increased use of mechanized agriculture in many tropical lands.
- 1960 AD Development of co-operative marketing, introduction of cash crops, and land enclosure in many tropical lands.

It has been said that true farming begins with the enclosing of the land. Whether good farming is possible without this is questionable; but it is certainly true that whatever significant developments have been made in agriculture in recent years, these would not have been possible without the land having first been enclosed. What is also certain is that the future of agriculture is inevitably linked with the past, and the following quotation is worthy of consideration in this respect:

All the earlier ideas and improvements and techniques came to Britain from overseas—mostly from the Mediterranean basin; from the Middle Ages onwards the initiative passed to NW Europe and eventually to England, which became the focus of the industrial revolution in the nineteenth century. The initiative will not always remain with Britain; it has already spread to America and is now spreading to central and eastern Europe. Such is progress; nothing is stationary, nothing final. The study of the past, therefore, helps us to understand the present and plan for the future.

E. C. Curwin *Plough and Pasture*

Languages. The most important connexion between languages and science in general is that a clear statement of an idea depends on the accurate use of words; and the methods of science are important in arriving at correct definitions. Vocabulary will be greatly increased, moreover, by the study of science subjects, as many words in common use are scientific in origin. Such words should be defined whenever they are first used in lessons. In Appendix 1 will be found a list of definitions of many of the scientific words used in this book.

Many idioms in common use in local languages have their source in rural pursuits and occupations. 'Ploughing your own furrow' (meaning to follow one's own chosen course), 'making hay whilst the sun shines' (which means to take advantage of opportunities as they occur), and 'counting your chickens before they are hatched' (meaning to take for granted that which you have not yet got), are three examples from the English language to illustrate the point. Teachers may be able to collect more examples from their own languages of idioms which refer in a similar manner to rural activities.

There are many verses and passages to be found in literature which may be used to introduce aspects of rural science work. For example, the following lines by Rabindranath Tagore could be used to encourage pupils to make close observations of a similar kind, and as a consequence, attempt to compose lines of their own:

Over the green and yellow rice-fields sweep the shadows of the autumn
clouds followed by the swift-chasing sun.
The bees forget to sip their honey; drunken with light they foolishly hover
and hum.

Similarly, these lines by the Nigerian poet, John Pepper Clark, taken from his poem 'Night Rain', suggest close observation of natural occurrences:

Great water drops are dribbling
Falling like orange or Mango
Fruits showered forth in the rain

The study of good writing encourages straightforward thinking and speech. Even in a scientific book, however, eloquence may be part of the process of conviction. Sir Albert Howard, in his book *An Agricultural Testament*, convinces us of the need for humus in the soil in the following manner:

Soil fertility is the condition which results from the operation of Nature's round, from the orderly revolution of the wheel of life, from the adoption and faithful execution of the first principle of agriculture—the processes of decay. The consequences of this condition are a living soil, abundant crops of good quality, and livestock which possess the bloom of health. The key to a fertile soil and a prosperous agriculture is humus.

But above all, the teacher must be aware that he is a language teacher at all times. If, as is being suggested in this chapter, rural science investigations are made the centre of interest to which as many aspects of all other subjects as possible are linked, then language teaching will be proceeding indirectly most of the time. It has been found that very often pupils acquire a far sounder command of language as a result of completing written and spoken work related to topics which interest them, than by the more usual formal type of unrelated language lesson.

Arts and crafts. Correlations with these subjects is of the greatest importance. Although gardening and agriculture are, in fact, applied sciences, they involve manual activities of many kinds; and they have an artistic aspect as well. The history of garden art has been referred to briefly already. It should not be forgotten that in addition to these broad examples of national garden art, ordinary people have always done their best to make their home surroundings more pleasant to live in by cultivating trees and flowers and other plants around them. In schools, this tradition may be continued. Out-of-doors, the artistically minded teacher will consider it important to try to achieve harmonious arrangements with his plants, both as regards their form and colour, and the relationship of their masses. Indoors, flowers may

be used to decorate the classrooms and as subjects for design work in craft lessons, such as needlework.

The techniques of art work (i.e. the ability to draw, use colour, and make things with the aid of tools) are valuable for much science work in schools, for there is often no better way of recording or expressing ideas and observations than to draw them. The making of small tools and implements will involve manual work, and the good teacher will think it important that these should be as functional and as well-made as possible.

To go fully into the educational value of learning to use the hands skilfully would be out of place in this book, and would, in any case, take up too much space. It has long been known that the arts have an importance in education beyond being merely useful, recreational or decorative. But in practice, the idea that such qualities as form and rhythm, which are the essence of all art and craft work, can have an effect on the moral character of our pupils, is usually ignored. Yet it was over two thousand years ago that Plato pointed out that:

the absence of grace, rhythm and harmony is nearly allied to baseness of thought and expression and baseness of character; whereas their presence goes with that moral excellence and self-mastery of which they are the embodiment.

The Republic: Book III 400

Just as we have realized that the time is now overdue for the scientific attitude to underlie our approach to knowledge in the schools, so is it necessary to appreciate that an artistic awareness must underlie our approach to practical activities. Together, these two attitudes should permeate throughout all school work. To put it simply, in addition to acquiring facts and forming ideas, it is necessary that there should be the opportunity in schools for pupils to do things well.

THE TEACHER OF RURAL SCIENCE

There is little doubt that this subject would improve greatly if an increasing degree of specialization could be brought into the training of primary school teachers in tropical countries. Because of its particular demands, it is the teacher with an informed attitude to the land and all that is connected with it, who will be able to achieve the greatest success. This does not mean to imply full-scale subject specialization at this level: but just as a school would benefit if there were a woman on the staff trained in domestic science or a man

experienced in woodwork, so it would be valuable to have a person skilled in the practical use of the environment. In the primary schools, it is specialized knowledge of the basic activities of living that is valuable, rather than advanced academic knowledge of subjects. In those countries where facilities available for giving this kind of specialized training to primary teachers during their initial training courses are generally poor, the need for an intensive in-service training programme in this respect would be indicated. Apart from this specialized training in his subject which may or may not be available, the rural science teacher will need to develop certain personal qualities and mental attitudes towards his job.

First and foremost is the need to have clear the meaning and significance of the scientific method of investigation, and a belief in its effectiveness. He must have the characteristics of the true naturalist: developing particularly the habit of observation and the technique of recording what he sees. He must learn to reflect on his own experiences, and question what he does not understand. Because the slow rate at which living things grow is related to many factors over which there can be no control, such as the seasonal changes, a necessary quality for anyone who is to cultivate plants is patience. Similarly, when dealing with animals, a sympathy towards their needs, combined with an unsentimental respect for them as creatures which are essential to man's survival on earth, is to be encouraged. Because much of rural science work is of a practical nature, an ability to use the hands to make things with the aid of simple tools is required; and in the modern world, with the increase in mechanization, an elementary understanding of power-driven machines is to be desired. It is to be hoped that this book may contribute to the development, in the rural science teacher, of these desirable qualities of mind and body.

All this is not to underestimate the importance of the teacher having a sympathetic understanding of the development of young children and their psychological needs, but this is a quality shared by teachers in all subjects. A good teacher is an authority on his subject; but a teacher of a science subject, instead of considering that his task is merely to pass on information, will appreciate that he has a larger responsibility in joining with his pupils in making discoveries, being prepared to admit limitation of knowledge but always eager to broaden it. In no school subject, especially in one concerned with science, is there any place for dogma. Above all, the teacher of rural science will realize that his work and the topics he deals with, are

part of a humane education of vital importance to all. As Dr Cyril Bibby has said:

Much as we need professional scientists and technologists, we need even more to produce a generation of ordinary citizens who are impregnated with the spirit of science, and this is the major challenge to scientific education. The nurturing of careful observation, disciplined imagination, willingness to face facts, humility in the face of complex problems combined with the determination and confidence to overcome them—these are the most valuable outcomes of good science teaching, and they are needed not just by that minority who will make profession of science, but by every single citizen.

(Part of an address to the 1962 Annual Conference
of the British Universities Humanist Federation)

RURAL SCIENCE AS A METHOD OF TEACHING

In this chapter it has been shown that rural science is a subject with many sides to it. It is a science subject; and as such, has significance in that it may encourage right methods of thinking and critical yet reasonable attitudes of mind, as well as a sound approach to learning. It is a subject which has great practical importance in lands with a rural economy. In a primary school, rural science is particularly valuable because its content can readily be identified with, and related to, the children's natural interests and activities; and the countryside becomes the workshop in which this learning takes place. It has been shown at some length how it has useful and interesting correlations with most other subjects in the curriculum, and is therefore ideal as a means of bringing unity into a teacher's work. To sum up, it may be said that although this book deals with rural science as a particular subject, teachers will find that the most satisfactory and rewarding approach for them to adopt, is to think of it as being, above all, a medium through which all kinds of learning can take place.

CHAPTER 2

Preparation for Practical Work

THE SCHOOL GROUNDS

The most important aid that the rural science teacher has at his disposal, is the area of ground on which the school itself is built. The subject cannot be taught effectively without making full use of this facility, as it is essentially a practical subject. This is not to say that a teacher in a town school, or a school which has only limited space for a garden, cannot teach the subject at all. Many topics may be developed with the aid of plants grown indoors in tins or boxes or earthenware pots, or in the smallest of flower-beds around the school-room: enthusiastic teachers will make the best use of whatever space is available. In the notes which follow, however, it is a school with a fair-sized area of ground suitable for cultivation which is considered as being most typical.

The land surrounding many schools is sometimes not used to the best advantage, and there are often valid reasons for this state of affairs. There may, for instance, be geographical factors which limit the growing of plants, such as the type and depth of soil, or the climate; but more likely, it is that teachers have not been given guidance on how to utilize the garden as an aid to their lesson work, and so make their immediate surroundings an influential part of education. Pupils spend a large part of their lives at school, and the environment will have an effect on their development for better or worse. Teachers have a responsibility to make their schools as pleasant and as educationally useful as they can, and the purpose of this chapter is to outline some of the ways in which this might be done.

The general layout. An important point to bear in mind is that the garden is to be used principally as an aid to teaching, and not as a place where the most profitable local crop can be grown to make money. It is not a schoolteacher's job to spend his time gardening commercially, or even producing food for home consumption, although, of course, produce from a school garden may be sold or eaten. Another aspect to consider is the amount of land to have actually under cultivation. Some schools in tropical countries have

several acres belonging to them, and the proportion of this being cultivated should never be so large that its care and maintenance becomes a burden to teachers and pupils alike. In most schools, a maximum of half an acre will be adequate for all purposes.

The manner in which to use this plot of ground will vary, of course, but a fully utilized school garden should include certain

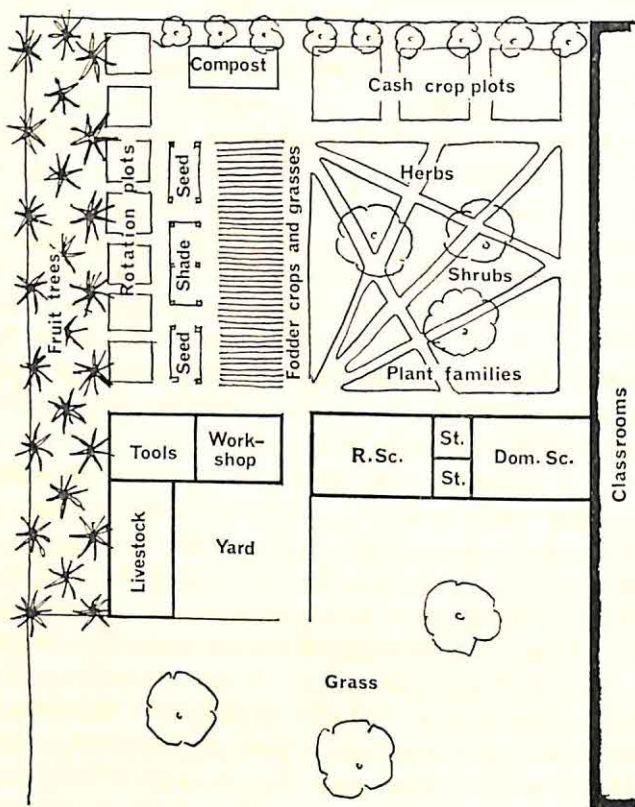


FIGURE 1. A layout for a school garden

essential sections. There will be a number of small demonstration plots (each about 5 yards square) for experimenting with different vegetable plants; a plantation of fruit trees may be used as a wind-break to the demonstration plots, or be sited elsewhere; examples of the so-called 'cash crops' may be planted in other beds; there will be space for various farm crops used as food for livestock; within sight of the school buildings will be flower-beds for decorative plants, whether annuals or perennials, including bulbs, climbers and shrubs. There may be special beds containing plants all botanically related;

and in this respect, the cultivated grasses, many of which are of great agricultural importance, should not be forgotten.

Whether this garden will be organized as one unit, or whether some pupils will be allowed individual plots to cultivate themselves, depends on the point of view of the teacher, and will, therefore, be found to vary. A compromise may be the best solution to this question: the pupils in the lower two years having their own independent 'class' garden; the pupils in the middle two years being mainly responsible for the work in the general school garden, including the demonstration plots; and the pupils in the upper two years being responsible for certain of the heavier tasks in the garden, such as digging work, together with the use of individual plots as space is available and as time allows.

The remainder of the school grounds is best planted with grass. Part of it, of course, will be used as playing fields for organized games. Elsewhere, a pleasant and beneficial effect will be obtained if various well-chosen trees are planted at suitable distances, both for children to sit under and to give shelter to any livestock which may be used to graze the grass.

The whole area will be improved if it is surrounded by a fence or hedge to form a boundary. There is an opportunity to make good educational use of this if different kinds of plants are used for each stretch of the boundary, so that their merits or otherwise may be compared.

Buildings for rural science should be sited in positions convenient to the place where the outdoor work in the subject will mostly be

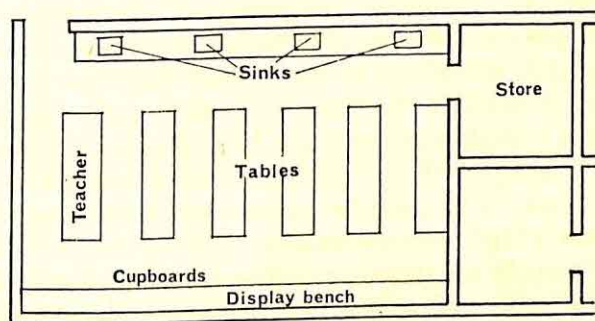


FIGURE 2. The rural science room

done. The following buildings would prove to be useful in any school garden:

1. A store for tools and other equipment.

2. A shade hut for the raising of seedlings.
3. A compost box.
4. A building, or buildings, for small livestock.
5. A special room for the teaching of the lesson work associated with the subject.

If the latter of these buildings can be provided, it should contain tables, rather than desks, and cupboards for the storage of specimens, collections and equipment. A supply of water and, if possible, a sink are equally valuable. (Figure 2.)

Preliminary soil preparation. An essential aspect of rural science work is to encourage a responsible attitude of mind towards the use of the soil itself, and its conservation. In Chapter 1 reasons for this have already been mentioned, and whatever teachers can do to further an awareness of the problems involved will be worthwhile. The soil must be properly prepared for cultivation, and what is more, kept in good condition whilst it is in use. Necessary preliminary tasks may include drainage, terracing, aeration of the soil (by deep-digging, for example), liming, maintaining fertility by manuring, providing shade in various ways, and increasing the water supply. As it is the humus in the soil which holds the moisture, which in turn carries in solution the plant nutriment (minerals such as nitrogen, phosphorus and potash required by plants), gardeners must make sure that this substance is plentiful in the top-soil. The making of compost may be the only possible method of providing humus for the soil; but, of course, fertility can be increased by other methods of manuring, such as by applying farmyard manure, by the digging in of a green manure crop, or by the application of organic fertilizers, e.g. wood ash, crushed bones or poultry droppings. In recent years there has been an increased use of artificial fertilizers in tropical lands: sulphate of ammonia (to provide nitrogen), and basic slag (to provide phosphorus), for example. There is certain to be a continuation of their use in the future, as the need for greater yields to be obtained from limited areas of land becomes obvious.

Tasks to keep the soil in good condition are mainly concerned with loosening the surface of the soil, to permit moisture and air to reach the roots of the plants and to prevent the spread of weeds. These include cultivating, rolling, hoeing and raking; and they are all additional skills which a teacher will need to include as part of his course.

WHAT TO PLANT

The problems of what to plant and of where plants should be positioned in the garden may present some difficulties. It will be found that the deciding factors are the geographical conditions of the locality in which the school is situated, such as (i) the altitude above sea level (which affects temperature); (ii) the amount of rainfall and the frequency at which it occurs (related to the seasons); and (iii) the aspect of the garden in relation to the prevailing winds, and the direction of the morning and afternoon sunlight.

General reference has already been made to some of the different kinds of plants which may be cultivated in a school garden. Here, the intention is to give a more detailed idea of what might be included so as to get the greatest educational benefit from them. Although some examples of each kind are mentioned, it would be impossible and beyond the scope of this book to give a complete list of all possible plants. Teachers who wish to find out more must refer to books specifically on garden plants. Information can also be obtained from nurserymen's catalogues; and by visiting the nurseries themselves, where plants can be seen growing and labelled so that recognition is possible. Agricultural officers could be asked to advise teachers upon problems specific to the locality concerned, for example, preparation of the soil and selection of plants.

Trees. When not grown as hedge plants, for which purpose many trees are suitable, trees are grown for shade, timber, beauty of form, foliage and flower. There are, of course, many different climatic conditions within the tropics, and choice will vary from territory to territory. For example, the Banyan tree (*Ficus bengalensis*) is a typical shade tree for low altitudes in humid lands; the Flamboyant tree (*Delonix regia*) is famous for its glorious mass of red flowers, and the Silk Cotton tree (*Ceiba*) has an equally fine display of pink flowers above its spiny trunk; for mid-altitude, drier regions, the many kinds of flat-topped thorn trees (*Acacia*) are common; whilst at the higher altitudes, even conifers, such as *Juniperus* or *Podocarpus*, may be suitable.

Shrubs. These may be distinguished from trees by their lower habit of growth, branching from near the ground. Representative examples are the Camel's foot plant (*Bauhinia*), Frangipani (*Plumieria*), *Hibiscus* and *Poinsettia*. Many shrubs are suitable for making hedges, amongst which are the various kinds of *Euphorbia*, for lower altitudes and dry areas; the thorny *Caesalpinia*, with yellow flowers and bright

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green, much-divided leaves, and *Duranta repens*, again with bright green foliage, are others. Some of the most interesting shrubs have a climbing habit of growth, and examples are the many kinds of *Bougainvillea*, and the various *Bignonias*, such as Golden Shower (*Pyrostregia venusta*) and *Phaedranthus buccinatorius*, with its large scarlet and yellow trumpet-shaped flowers. They should find a place in the garden covering walls or frames.

Although not strictly to be classified as shrubs, whenever possible a few examples of Palms and Bamboos should be planted, on account of their specially attractive stem and leaf formation and interesting habit of growth in general.

Herbaceous plants. These soft-stemmed plants are generally grown in borders by paths, or around the edges of grass plots in the school grounds. The annuals, such as Balsam (*Impatiens*) and Pinks (*Dianthus*), are popular with the younger children who like to witness the changes in plant growth which may be seen taking place rapidly. They provide masses of colour either when in beds on their own, or when sown amongst other kinds of plants, such as shrubs which may only produce flowers at long intervals of time. Many herbaceous plants are perennials, of course; and amongst these the bulbous-rooted kinds, such as *Canna*, are convenient to cultivate, because they remain alive in the soil during the dry seasons, although their leaves may die right down to the ground. Succulents too are useful for the drier areas. These plants have fleshy leaves; *Byrophyllum*, with green leaves tinged with brown at the edges, and *Gasteria*, with low rosettes of grey-brown leaves, are just two examples of the many possible kinds to plant.

Certain types of herbaceous plants are suitable for indoor culti-

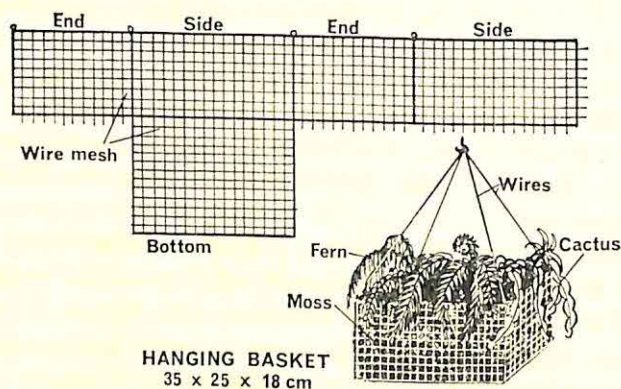


FIGURE 3. How to make a wire basket for plants

vation; and they may be grown either in tins or boxes, or supported in hanging baskets made of wire, containing rich soil, leaf mould, and moss. Various cacti, succulents and some decorative grasses, are attractive in tins, whilst ferns and orchids do well in baskets.

Vegetable plants. Many herbaceous plants, grown to be used as human food, are classified as vegetables. In the demonstration plots, a simple rotation should be planned to maintain the soil in good condition during the continuous cultivation required, and to help control weeds, pests, and plant diseases. At least four plots will be required for this purpose: rotating the heavy-feeding crops (such as the leafy *Brassicas*) with the so-called 'Pulse' crops (such as peas, beans, grams, etc.), the light-feeders (such as onions) and the root crops (such as cassava or potatoes). If some of these plots are to be allowed to rest for a season, either under grass or as fallow (i.e. growing nothing at all), or are to be sown with a green manure crop, as many as seven or eight plots will be necessary. There are, of course, other vegetable crops than these which have been mentioned, including the cereals (such as maize and millet); the cucurbits (pumpkins, gourds, etc.); yams; the egg-plant; okra; the coco-yam; arrow-root, etc. Some of these may be grown in a school vegetable garden, together with examples of spices, such as chillies, ginger, pepper, nutmeg and cinnamon; also various plants with medicinal properties may be tried, such as aloes, cassia, myrrh, lavender and so on. Local knowledge should be utilized in this respect, and children introduced to those plants which have proved to be of benefit.

Fruit trees. These are always an asset because the produce from them is pleasant to eat, interesting to observe whilst ripening, and in some instances the trees are of decorative value and able to give shade. Not all fruit plants are trees; amongst the so-called 'berry' fruits, the small herbaceous strawberry should be tried in all schools where conditions are suitable. Of the true tree fruits of tropical lands, the banana and citrus fruits will be mainly grown; but there are many others, including the pawpaw, avocado, loquat and mango, and nuts such as the cashew and peccan nut. In certain regions, pineapples will be successfully cultivated; and they are of interest because it is the whole flower-head which ripens into the fruit, and because the plant has unusual modes of vegetative propagation. Elsewhere, the grape vine and other fruits of sub-tropical origin may be tried.

Other crops. There will be a place in the garden for examples of a few of those plants likely to be seen growing as food for livestock. Chief amongst these are the grasses; and the specimens may be

planted in small plots, or rows, so as to compare their habits of growth and other characteristics. Maize; sunflowers; various kinds of beans; such plants as edible canna, sweet potatoes, and even temperate cereals like wheat, oats, and barley, may all be grown as fodder for livestock.

Although it would be a mistake to plant too large an area with a crop grown locally for sale off the farms, some of these important plants may be grown to demonstrate the possibilities in this respect, and to introduce the idea of economic geography from an agricultural point of view. Such plants as the beverages (coffee, cocoa, maté, and tea); fibres (jute, hemp, manila, cotton, coir, kapok, and sisal); oil-bearing plants (castor, coconut, ground-nut, sesame); plantation crops (sugar, pyrethrum, rubber, tobacco); and cereals (rice, maize, sorghum, and millet) may be tried.

SMALL LIVESTOCK FOR SCHOOLS

The interest which nearly all children show towards young animals is in itself sufficient reason for including the care of small livestock in any school syllabus of rural science. At the same time, children may be encouraged to develop an unsentimental attitude towards animals, as well as the self-discipline and confidence which are essential for the proper handling of farm livestock. Furthermore, the responsibility of the task will be realized, and children will grow up aware of the need to avoid cruelty, or a callous indifferent attitude towards animals and their welfare. Care of small livestock also allows unequalled opportunities to learn the facts of birth, reproduction and death, as well as other biological facts about animals. An understanding of the basic needs of all domesticated livestock will prepare the way towards instruction in animal husbandry, at a later stage of education.

The rearing of chicks, the keeping of pigeons, the breeding of rabbits, and the care of young calves, are perhaps the activities connected with livestock most suitable for children in school; but this does not mean that other animals should not be considered, if they seem more suited to any particular locality. Pigs, goats and sheep, for instance, have all been kept successfully in schools in various parts of the world, as well as numerous kinds of smaller creatures, such as guinea-pigs.

It is essential that animals are kept in buildings suitable for the purpose: there is no more certain way of testing whether livestock

are being looked after properly, than by examining the places which they are expected to inhabit. To manage livestock efficiently, it is necessary to have some understanding of the characteristics and needs of the particular animals concerned. Some basic facts are included in the following paragraphs.

Poultry, especially newly hatched chickens, are always of interest

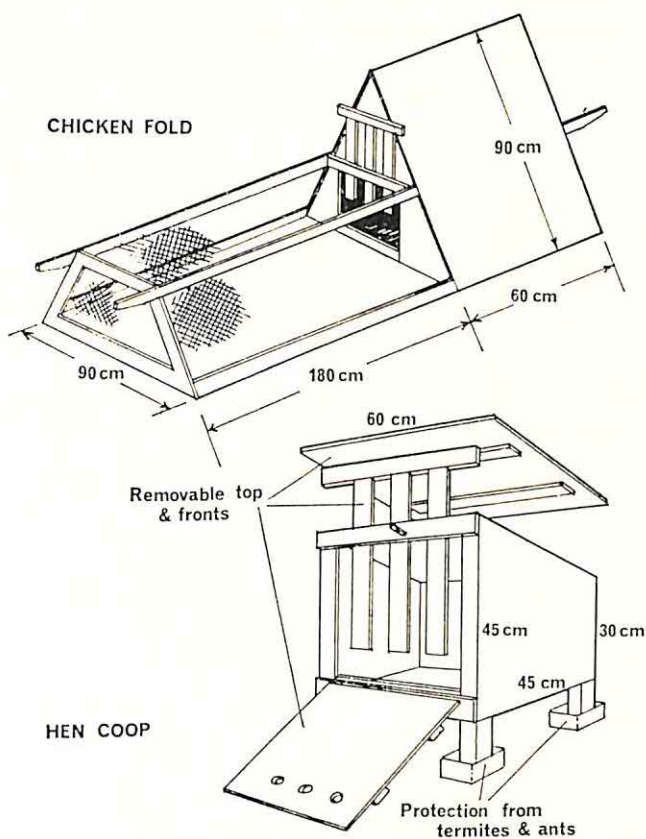


FIGURE 4. Equipment for chick-rearing

to children. They may be used to teach facts about how a young bird develops from an egg. The idea of incubation, also, can be introduced at this time, stressing such facts as that warmth is necessary for the eggs to hatch, and that the young chick feeds on the food that is within the shell, before it is fully grown. A hen with a sitting of eggs will require a well-built coop in which to live during the incubation period. This should be large enough for her to move about in and

stand up, but no more. It must be possible to lock it up at night, and should be protected from insect pests, such as termites and black ants, and from other kinds of larger vermin. After the chicks have been hatched, they will need a wire-netting pen in which to run about in safety, and in which food and drinking water can be supplied to them in clean containers.

Pigeons need a 'cote' in which to live. This may be a small wooden structure raised on top of a pole, and provided with perches for the

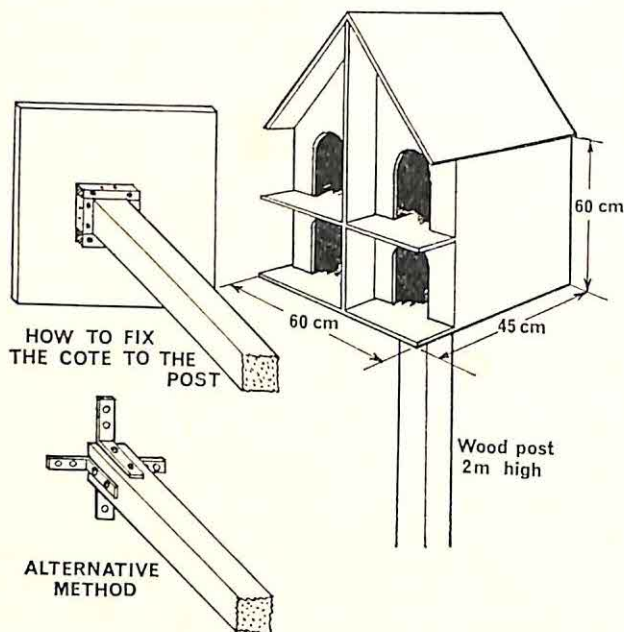


FIGURE 5. A design for a pigeon cote

coming and going of the birds. Some breeds do better in a larger house, perhaps with wire-netting around to form enclosed 'flight'. In tropical lands, there is a danger of tame birds being taken by birds of prey if they are allowed to fly about freely in the open. Pigeons will breed in captivity, and they may be given an earthenware pan in which they will build a loose nest and lay their two white eggs. The most attractive kind of pigeons to keep are perhaps those with white feathers and a wide-spreading tail, which are known as 'fantails'. They have the great advantage that they do not fly far away, and do not object to being handled. There are other varieties of pigeons equally attractive in appearance, from the fast-flying 'racing' breeds,

to less active kinds, such as the Modena. It should be remembered that pigeons are grain-eating birds, and they may be fed on millet, or other similar seeds. They must have a constant supply of clean water available for drinking.

Rabbits are kept in hutches: small, wooden houses either kept inside a building, or with a waterproof roof, out-of-doors. There should preferably be a separate sleeping compartment. Rabbits must be kept clean and protected from pests and vermin, and fed regularly. As they gnaw their food, they enjoy a diet of roots, but will also eat green leaves of almost any kind, including grass and many wild

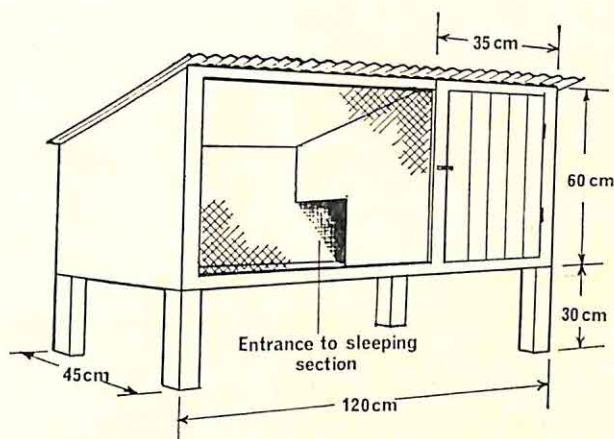


FIGURE 6. A rabbit hutch

weed plants. They do not drink much water, but if the plant food they are given is dry, it should be provided. Rabbits will breed when a few months old; and if they are permitted to do so, the male should be kept separate from the female whilst she has her family with her.

Cattle to be seen in tropical lands usually possess the distinctive 'hump' and large 'dewlap' under the neck, but there are European breeds of cattle which have been introduced into tropical countries, and which may be crossed with the indigenous breeds. The latter are usually smaller than those imported from overseas, and do not normally yield such large quantities of milk; they may, however, be more resistant to disease. Young calves make suitable pets, and are most instructive and interesting to watch whilst growing. They need a pen under cover so that they may remain dry in wet weather, and get shade from the sun. As well as good bedding for them to lie on,

they must be provided with a manger, or rack, in which grass and hay may be fed to them. It should not be forgotten that calves require drinking water, as well as a supply of fresh milk.

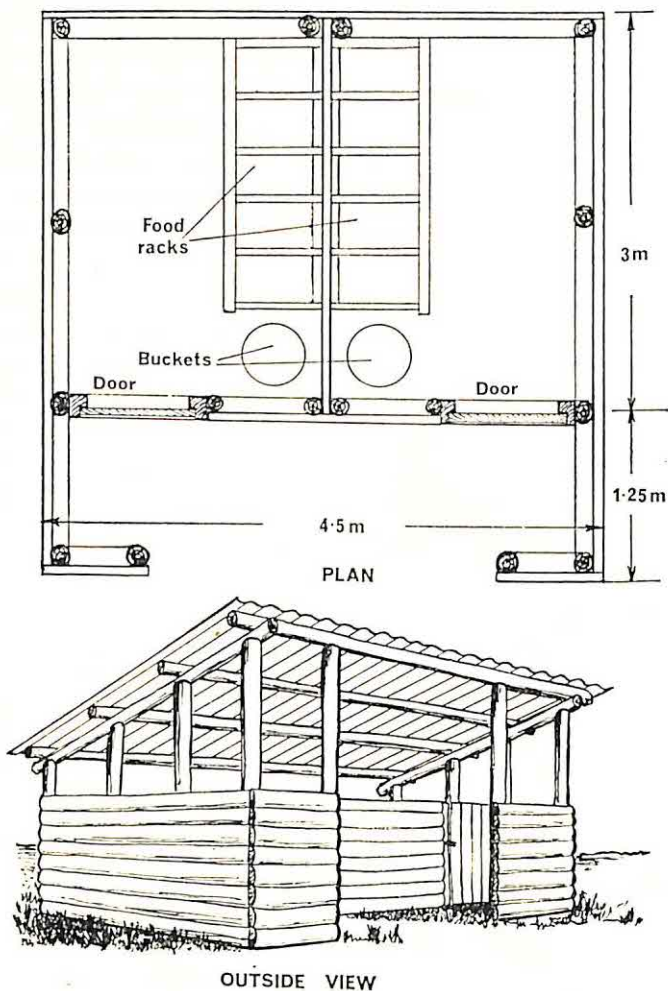


FIGURE 7. Housing calves

FARM STUDIES

Although it is not feasible for teachers in primary schools to start farms, there is much connected with farming that is of interest to children. From their earliest days, boys and girls who live in rural areas will have been familiar with the age-old processes of soil

cultivation, and will have witnessed the regular round of tillage, seed-time, and harvest on their parents' farms. Children living under such conditions will often grow up alongside the farm livestock—the goats, sheep, poultry, and cattle; and they may have helped in the task of herding them. But it is a fact that for many reasons, the needs of the people and the processes of agriculture are changing rapidly in tropical lands; and it is fitting that children should learn something of these changes which are taking place around them, and of the reasons for them. Ideas such as conservation, co-operation, mechanization, and the enclosing of the land, the value and purpose of cash crops, and the transition from a subsistence economy to one based on monetary exchange, are all being introduced and accepted; and an understanding of what is involved is essential, moreover, to future citizens of these lands, whether they are to be farmers or not.

One possible approach, particularly for schools in urban areas or situated in places where the soil cannot be cultivated or stocked, is for a school to 'adopt' a farm elsewhere. By means of correspondence, the teacher is kept informed of what is going on seasonally; and the pupils in turn, may therefore have their interest kept alive, until the day when they can actually visit a properly farmed holding. This idea does, of course, depend on the co-operation of an interested farmer, who will also be willing to maintain a link by letter with the school.

The most satisfactory approach to farm studies will probably be found to be by means of a series of farm visits to suitable holdings, institutes, or other agricultural establishments within reach of the school. By this method, every aspect of farm work can be observed at first hand, including the various farming systems, the cropping plans (noting the food plants grown specially for livestock as well), the animals, the methods of ensuring that health and hygiene is maintained on the farm, the buildings and farm equipment, and many other activities. Careful records should be kept of such visits, because although a farm visit may be considered to be a practical activity in itself, it will be in the associated lesson work that teachers will be able to stress the main points that were under observation.

MAKING COLLECTIONS

Collections are important in science work for many reasons. The teacher himself, for example, will be well advised to make his own semi-permanent collections of specimens to use in support of his lessons. These will include such living and non-living objects as

fruits, seeds, soil samples, rocks and stones, tree barks, cones, insect cocoons, the comb from hives, etc. A collection of pressed grasses is something which will last a long time if cared for whilst it is in store, particularly guarding against the damage which can be done by insects. Bones and skulls, feet and mouth parts of small mammals and birds will be useful for making comparisons. In fact, the possibilities are very great, and will only be limited by the enthusiasm of the teacher. It should be realized that if such specimens are required to form the nucleus of a school 'museum', a good storage cupboard or room is an essential.

Pupils should be encouraged to bring objects which they have

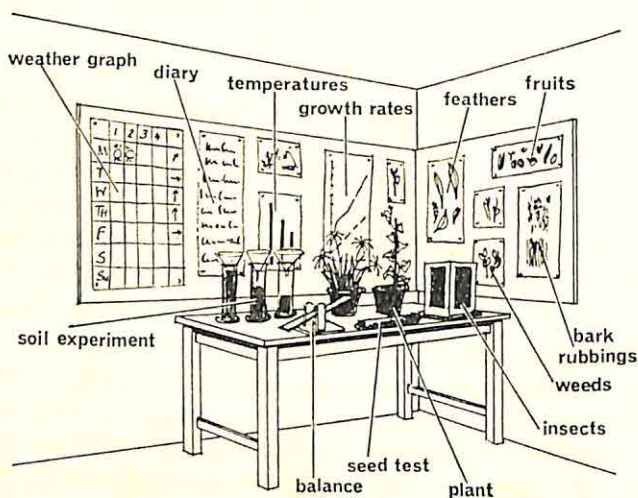


FIGURE 8. A view of a nature corner

collected to school, and the place for these to be laid out is in the *Nature Corner*, where they will be kept under observation for short periods of time. There ought to be a small table, or shelf, in each classroom suitable to hold a number of jars of water containing flowers, as well as larger objects, such as insects in cages, pot plants, and experiments in various stages of completion. On the wall behind the table, there should be space where other specimens, such as mounted feathers and seeds, may be pinned up. This is the place, also, for the weather charts, and records showing the layout of the whole garden, cropping plans for demonstration plots, results of experimental work, observations, etc. Specimens in the nature corner will need to be labelled adequately; and this may be done quite simply by noting (i) name (either in vernacular, in English or

scientifically); (ii) where found; (iii) when found; (iv) brought by whom; (v) other remarks. Under this latter point, it may be of interest to write down a suitable question, which may only be answered as a result of observing the object, as a means of drawing the pupils' attention to some important aspect of its form or appearance. If the identity of an object, or name of a specimen, is not known teachers should encourage the children and work with them to find it out, seeking the information in books or from other people. The teacher should never be afraid to admit that he does not know all the answers to the questions children ask, but he should always seek, if possible, to find them out.

OTHER PRACTICAL AIDS TO TEACHING

Rural workshops. In most parts of the world, a rural community includes many people in occupations not so directly concerned with tilling the soil or caring for livestock as the farmers themselves. In the villages will be found woodworkers (constructing buildings, carts and wagons, furniture and farm implements); leather workers (caring for the harness of the pack animals, oxen and, in certain countries, horses or camels); blacksmiths or ironworkers (building or repairing farm tools and implements); potters (who out of moist clay mould vessels in which all sorts of produce from water or milk to grain or seeds will be stored); masons (people who build in stone); thatchers (making the roofs of buildings waterproof); and many other craftsmen. Teachers should not forget these people, and ought to include some study of their activities.

Rural science centres. Teachers cannot be expected to make their gardens attractive and educationally useful if they have no means of stocking them, initially, at least. It is here suggested that a possible way of overcoming this problem would be for regional education authorities to set up rural science centres, organized by a specially appointed person. One function of each centre would be the development of garden 'nurseries' where plants of all kinds could be propagated and raised, for distribution to schools in the region. At the same time, funds must be made available for the purchase and replacement of tools, seeds, and sets of simple laboratory equipment suitable for the experimental work related to the subject. The centre could control the spending of such funds and be the place from which the various items required by each school would be obtained. What is certain is that until educational authorities adopt a more realistic

attitude towards the needs of this subject and make provision for it materially, as for others more conventional, improvement will not take place.

Another function of the centres would be the establishment of local museums and display rooms to which teachers could come with parties of pupils. There could also be an information room which would answer teachers' problems concerning the identification of species, etc., and from where teachers could obtain advice on the best way to deal with particular aspects of the syllabus. With the latter in mind, it might prove that near to the teacher training college within the region would be the best place for such a centre to be situated. Because they would be in contact with the agricultural, veterinary and forestry departments of the region, they could do much to keep vital and up-to-date the teaching of rural science in general, especially if an enthusiastic and knowledgeable person were in control.

Libraries. Without books for reference and further information, both for the use of teachers and pupils, no school subject, however practical, can be taught properly. Although the basic textbooks will be required in each school, there is a need for a larger reference library to be established in each region, and this could also be attached to the rural science centre mentioned above.

ORGANIZING PRACTICAL WORK

The manual tasks related to the care of a garden may become a great burden unless they are very carefully organized. Teachers concerned should think carefully about how much of their teaching time they can permit to be taken up by work of this kind; it is suggested that this should never exceed half the allocation of time for the subject with each class. If necessary, the area of land under cultivation must be reduced, or the number of different kinds of plants or activities engaged in, limited. But it must not be forgotten that the growing of plants is the basic activity of rural science in schools. Teachers will find it necessary to plan carefully in advance what plants they will require during the term; whether flowers, vegetables or trees. In addition to ordering plants, or buying seeds, they will need to ensure that seedlings or cuttings are at the right stage of growth when required for use in class. An important part of the teacher's function in science activities is to have the right materials ready at the right time. Errors or failures are bound to occur in gardening, particularly where several factors are beyond the control of individual effort; but

teachers should not be easily discouraged. If something fails on one occasion it is always worth trying again the next season, when it will probably succeed.

Teachers are often reluctant to experiment in the garden, however, because they do not feel confident enough to organize their pupils effectively. There is a need for some degree of division of labour. The school garden should be in the control of one member of staff and under the overall authority of the headmaster. In this way, seasonal tasks may be co-ordinated, duplication avoided, and time not wasted. Garden tasks should be graded in the scheme of work, according to the ages of the pupils: those requiring greatest energy and skill, such as digging, manuring or fencing work, or vegetative propagation and transplanting work, would be allotted to the older pupils. It will be suggested in the next chapter that in consideration of the manner in which children change and develop during the six years of their primary schooling, the course in rural science should be divided up into three stages. The topics considered appropriate for each of these are listed on pages 53 and 54, and the practical garden work will be closely related to these. Suggestions are given under many of the headings throughout Part Two.

All garden tasks should be demonstrated first so that tools are used properly and energy not wasted, and to give understanding of what is required. The purpose of the work should be carefully, but briefly, explained, and the principles underlying the various activities stressed. Planning is essential, and the careful thinking out in advance of how to arrange the practical work from term to term will give the necessary confidence, and rewards in the form of interested pupils, and a well-stocked garden kept neat and tidy.

RECORDS

It is valuable teaching to encourage the keeping of records in respect of all practical activities and observations. They will give meaning to much that is done, and a sense of satisfaction to the pupils.

As regards plant life, records may be kept of sowing times and seed rates, crop yields, amounts of manure and fertilizer used, pests and diseases encountered; in fact, in connexion with each and every task, however simple.

The same applies to livestock records: they may be kept of the amount of food given each day, the times of feeding, of all births and deaths, sales and purchases, growth rates, and so on. Although such

records should be kept as simple as possible, they should be considered an important introduction to much lesson work, and a true basis of the scientific approach.

Pupils' record books should be sufficiently robust to be carried out-of-doors with them, and used in the field. They would, ideally,

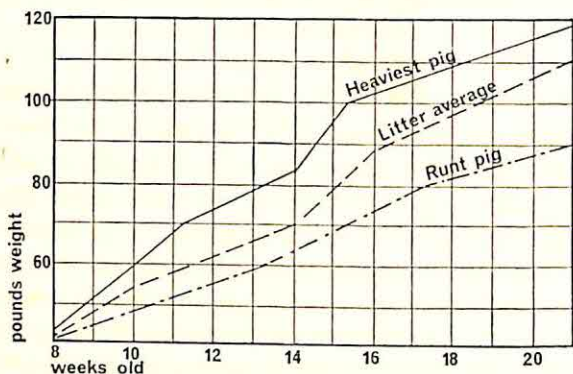


FIGURE 9. Example of a method of recording, using a graph

have stiff backs and be small enough to fit into the pocket. They may have lined paper or plain or both; but in any case, they will be used for graphic records as much as written notes, and therefore should have pages made of a paper suitable for drawing. Books should be taken in by the teacher from time to time, and corrected, as in other subjects. As regards classroom records, it cannot be emphasized too

TASK PROGRESS RECORD					CLASS VI
Topic	Task	Date	Time	Place	Remarks
Soils	Testing alkalinity in Compost	20/8	0900-1030	R.Sc. room	Completed tests. Acid results. Compost limed

FIGURE 10. An entry in a teacher's class progress record

much that, in science lessons, it is invariably bad practice to give pupils either written notes or blackboard diagrams to copy into their books. They have little value or meaning to the pupils, and the method is contrary to the scientific approach. Pupils' notes should be individual records of what has taken place; and drawings of specimens must, whenever possible, be taken from the real object.

Another important form of recording is by means of the 'Nature Calendar'. This is a method of recording observations specifically concerned with dates and times. Examples are the dates of the first appearance of seedlings above ground; the length of time for fruits to reach maturity; the changes in the weather; and the growth rates of animals. The method of layout may be pictorial for the younger pupils, or in note form for the older ones.

Finally, mention must be made of the teacher's own notes and records. As regards gardening activities, it is essential that records are kept of planting schemes, long-term programmes, seeding times and rates, harvest times, crop yields, and completed activities in general; they will be required for future reference when the various schemes reach completion. It will also be found necessary to keep some kind of record of progress made with each class in the various topics they are dealing with at each stage; and as regards the upper classes, a record of which pupils have completed which assignments. At the end of each term, an attempt may be made to evaluate the work carried out if such records have been kept conscientiously.

CHAPTER 3

Preparation for Lesson Work

CHILD DEVELOPMENT AS A GUIDE TO METHOD

It can be observed that the developing personality of a young child has two aspects: one, inward-looking, shown by the need to feel secure; the other, creative, and becoming obvious, as the child grows, in the urge to explore and experiment. As we all know from our own experience, these will remain throughout life, to determine habit and behaviour. The well-being of adults very largely depends on the balance which is maintained between these two characteristic needs: to possess and to create. Because of this, these comments are important to teachers: the adults in charge of children in schools, by their own attitudes and methods, can help to develop both aspects of the pupil's personality, by providing opportunities for experiment and creative activity within an atmosphere of security and approval. We have a great responsibility to choose our methods carefully and throughout this chapter guidance is offered in this respect.

Primary school children in tropical lands are usually found to be within the age-range, six to twelve. There will, however, be some pupils who are well over twelve, and it is possible there may be some not yet six years old. It will be seen that the primary school is concerned with a wide age-range, extending over an important and vital period of children's lives.

By the time a child first comes to school, he is ready as a person to adjust himself more and more to the world in which he lives. He is prepared to start a social life with children of his own age, and to benefit from the experience of observing and copying others older than himself. He will have already gained control over his own limbs to a remarkable extent. He will, moreover, have learnt how to talk and express himself in his own language, although he will not yet have learnt how to read or write. He will have found that he has power over many things, but that there are some things over which he can have no control. He will certainly have met frustration and even defeat in his active investigations of the material world around him. So far, he has been mostly preoccupied with the world represented by his mother and the home, but he now seeks to discover

what lies beyond. This he will do by means of practical activities of his own devising. He learns by doing: a process which will be the chief means to his education throughout life.

But the personality of the child changes as he grows, and his methods of learning actively change also. It is possible to distinguish three stages through which he will pass during the period with which we are concerned whilst he is at the primary school; and each of these gives a clue to appropriate methods of teaching.

During the first stage his activities are all concerned with 'play'. He lives for much of his time in a world of his own, pretending to be someone else, or identifying himself with objects or animals. He is very much an individualist, and although he likes the companionship of others, he shows little inclination for true co-operation. He is an enthusiastic collector, with the ability to make almost any kind of object satisfy the demands of his imagination; and he enjoys drawing and modelling as methods of expressing what he has to say. Teaching methods must respect these natural child activities.

Later, he will pass into a stage of development in which he becomes more aware of others. He is less inclined to 'make believe', and begins to form proper relationships with other children. As it is still through practical experience that he learns best, the teacher will be able to make good use of co-operative activities at this stage, in order to help the learning process. The child is still a keen collector and artist, but his understanding is growing all the time as he learns to read and write, and he will be able to absorb all the facts that a teacher can give him in answer to his innumerable questions. He slowly becomes aware of adult standards, although often reluctant to accept them.

In course of time, as he progresses towards his secondary school days, a third stage of development is entered. As the physique of a boy or girl changes gradually, many tasks more like real work become possible. At the same time, his interests widen, and he makes more use of the processes of logical thought and reasoning. He shows greater powers of application in his lesson work and will be ready to accept a greater degree of responsibility. An independence of spirit shows itself in all his activities, and in self-reliance where work is concerned. At this stage also, such changing characteristics of personality which can be recognized will again affect the choice of teaching methods. At all stages of development, it is necessary for the teacher to be aware of the danger of using materials and methods beyond the ability of the pupils concerned. In order to encourage a feeling of

progress and confidence, necessary to the harmonious development of the personality, tasks should be suited to the capacity of the children and encouragement by reasonable praise offered when success attends their efforts.

TEACHING METHODS

Methods for the first and second primary years. In Chapter 2 it was suggested that the two classes of younger pupils should have their own area of ground to look after and make into a garden. In it individual children could sow seeds in flower-beds, which they could call their own personal plots, where they would try out simple experiments and make observations suited to their age and interests. In these class gardens, also, would be the space and equipment for supervised play: the sand-pit, the climbing frames, areas of grass, and materials to build with, etc.

Though rural science lessons at this stage will mainly take place out-of-doors, either in the garden or on nature walks, teachers may encourage classroom discussions afterwards to bring out ideas and lesson points. These should be conducted informally and every opportunity should be taken to widen the scope of the lessons by introducing poems or verses, lessons about persons or places, and, of course, nature stories. Suitable classroom activities for the children themselves will mainly take the form of drawing, painting and model-making, related to what has been done in the garden, or seen in the neighbouring countryside. Children of this age will enjoy caring for pets, and the many experiences they have whilst making them their friends will give valuable training in the handling of animals.

Above all, at this stage, teachers should be concerned with trying to educate the senses, leaving formal 'understanding' to look after itself. This does not mean, of course, that information should not be given. On the contrary, questions should always be answered as seriously as they are asked, for it is wrong to give children the idea that certain topics are too difficult for them. But if small children were to become sensually familiar with their surroundings through comparative experiences, such as the feel of dry soil and the texture of rock surfaces, the scent of flowers and the taste of fruit, the hardness of wood and the softness of leaves, the coolness of water and the warmth of sunlight, the power of the wind and the protection of shade, they would be given a sound foundation upon which a structure of more formal knowledge about rural science could be built later in their school years.

To sum up, it will be realized that a kind of activity hardly to be differentiated from play, yet subtly directed towards the chosen ends of the teacher, will be most successful during these early years of the children's primary schooling. To achieve this, at this stage of education perhaps more than at any other, the teacher's role is that of a sympathetic and encouraging accomplice, rather than that of an instructor.

Methods for the third and fourth primary years. The care of the demonstration garden plots, it has been suggested already, is to be the particular practical responsibility of pupils in these years, and this work will no doubt occupy much of their time. Whilst this outdoor work is proceeding, teachers must take whatever opportunity they can to bring out the essential points of the topics, and to give whatever instruction in gardening techniques is necessary. There are some topics, however, not necessarily related to gardening work directly, which will be included in the scheme of work as well. It is suggested that the method most suitable for these, and one which is particularly appropriate for pupils at this stage, is to utilize, when ever possible, the project approach. On page 48 details are given of how to plan projects; and throughout Chapter 5, examples are included of suitable topics to treat by this method. It should be appreciated that although the examples in this book are specifically for this age-group, for the reasons previously stated, it is perfectly feasible to organize successful project work, either with younger pupils lower down the school, or with pupils in upper forms.

These then are the methods proposed for middle school pupils: practical garden work including demonstrations and experiments, and some associated lessons; together with a series of broad projects on topics concerned with other aspects of rural science, such as those related to farm studies.

Methods for fifth and sixth primary years. Children at this stage are in need of a more systematic knowledge and understanding of the subject, even if only because of the requirements for examinations which are still held in some tropical countries at the end of the primary years. Ways should be thought out of enabling pupils to produce work which is a result of their own individual effort. One suitable approach which is a development of the project work of the previous stage, is to set individual assignments in certain topics. The intention here is to give the pupils the chance to investigate a problem and write an illustrated report on it. The accent should be on effort and originality based on specially recorded observations and

study, rather than on the repetition of previously taught lessons. Examples of such assignments are given in Chapter 6 whenever suitable topics occur, and further information on planning is given on page 49.

It is likely that a large proportion of the teaching time during these years, however, will now be spent on lessons of a more formal character than hitherto. Whilst not underestimating the value of this kind of teaching, even in a practical subject, it is essential that such lessons are planned properly if they are to be effective. The teacher must ask himself before beginning his lesson, 'What are the main ideas of the topic which I am attempting to bring out in this lesson? How am I going to introduce the lesson? Have I chosen appropriate pupil activities to follow the teaching stage? Have I chosen the most suitable method for the teaching of new material?' Above all, it is essential to have clearly in mind the purpose of each stage of a lesson. To give guidance in this respect, ideas on how to plan a lesson are included in the next section, followed by specimen lessons suitable for pupils at each stage of development.

PLANNING CLASSROOM LESSONS

The plan of the lesson itself should follow a pattern based on the scientific method, that is by proceeding from the known to the unknown, by investigating problems by means of experiment based on observation, accumulating evidence by means of records, and drawing conclusions from such evidence. In effect, each lesson will require to be divided into three or four parts:

STAGE 1: The introductory stage. What is known already by the pupils about the topic to be dealt with will be the starting point of the lesson. Though usually short, it is nevertheless an important stage, as it is the opportunity to bring the pupils' minds on to the subject, and for the teacher to estimate the extent of their understanding. As it is in a sense a revision stage, it is often best conducted by means of question and answer, and a summary made on the blackboard of the relevant statements. This will lead on to a further statement of a problem to be solved, or an idea to be investigated.

STAGE 2: The teaching stage. In rural science lessons, this will more often than not make use of one of the following three alternatives:

(a) *Indoor or outdoor observations.* If specimens are brought into the classroom, there must be sufficient number of them for all pupils to be able to observe what they are expected to note. Their attention must be drawn to the important features of the objects, so as not to

be distracted by less essential facts. Use of the blackboard will help their 'seeing'. There will be other occasions when outdoor observations will be made: again, careful preparation is necessary. Pupils must always be given clear instructions as to where the objects concerned are to be found, and may be told to return to the classroom afterwards, if preferred, for the pupil work stage which follows.

(b) *Demonstrations and experiments.* It is important that the teacher should try out any practical demonstration before doing it in a classroom. It is also essential that the necessary equipment is made ready beforehand; and if pupils are to try experiments themselves, sufficient apparatus and an adequate number of specimens must be available. Recording will be an essential 'follow-up' after a demonstration, and teachers should consider how they want their pupils to do this. Some simple procedure should be thought out, and used consistently, so as to establish good habits of work in this respect (see Figure 12 below).

(c) *Oral teaching.* Though this is a method most commonly used, teachers do not always pay sufficient attention to technique in the presentation of their material. Oral work must never be over-long, and though this will depend on the age-range of the pupils, generally no more than three or four facts should be considered in each lesson. The facts will need to be explained simply, yet accurately; and it is in this respect that adequate and clearly understood background knowledge, together with the experience gained from the teacher's own practical studies in rural science, will prove to be invaluable. The language used must be appropriate to the pupils' understanding: to achieve this, preliminary thought is again important. A sure sign of good teaching is the use made of suitably chosen, pertinent questions. The benefit of these to the pupils is that they keep the mind on the relevant aspect of the topic, and enable them to draw conclusions for themselves; the advantage to the teacher is that by questioning the pupils, he can obtain a clear appreciation from their answers of how much his teaching has been understood generally, and of the degree to which each pupil has comprehended the facts. Many examples of suitable questions are included in Part Two.

The blackboard is a teacher's chief aid in this kind of lesson, and two factors contribute towards success in the use of it. The first is careful observation: only as a result of this is it possible to reproduce effectively, true pictorial impressions of objects and ideas. The second factor is the need for practice: by constantly trying out one's ideas, a rapid and informative manner of drawing on the blackboard can be acquired. But blackboard work involves writing as well as

drawing, and here practice is again the secret of success: simple, yet accurate statements, well-written with a good choice of words, are required to learn how to use the blackboard whilst oral instruction is taking place. The objective of the teacher should be so that by building up summaries or producing graphically visual images, the pupils can see what he is talking about as well as hear it.

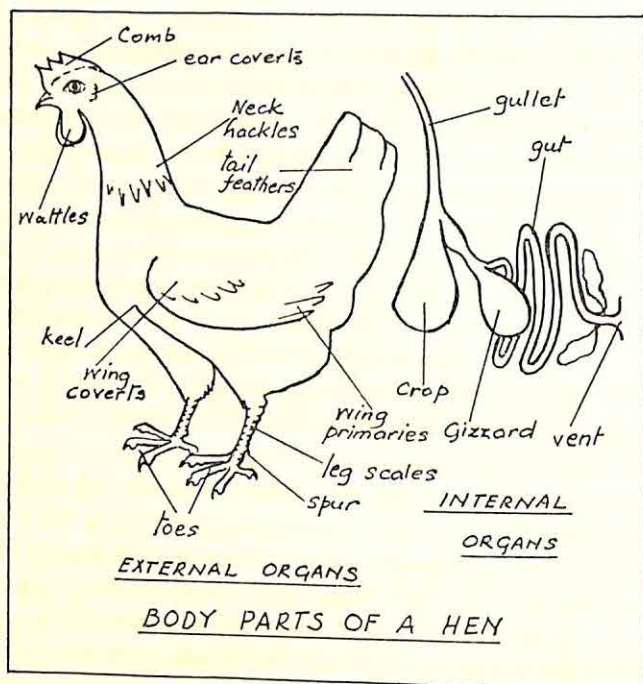


FIGURE 11. An example of a clear blackboard diagram

STAGE 3: Pupil work stage. In science lessons generally, this stage often means the recording of observations, demonstrations, or other practical work completed. More often than not, especially amongst the younger pupils, to make drawings is the method of recording more appropriate than any other. Although accuracy is obviously desirable, teachers should not be disheartened by a childish form of expression, Clear labelling of their drawings, however, must always be demanded, as this is a guide to proper understanding.

For pupils to record demonstrations, no long written description of the apparatus used is necessary; just a drawing and a simple statement of what has been seen will be sufficient, followed by a note on what happened, and the conclusion, as shown in the figure.

An alternative method of work which can be used in science lessons, particularly with the older pupils, is the writing of descriptive passages. The copying of teachers' notes or drawings from the

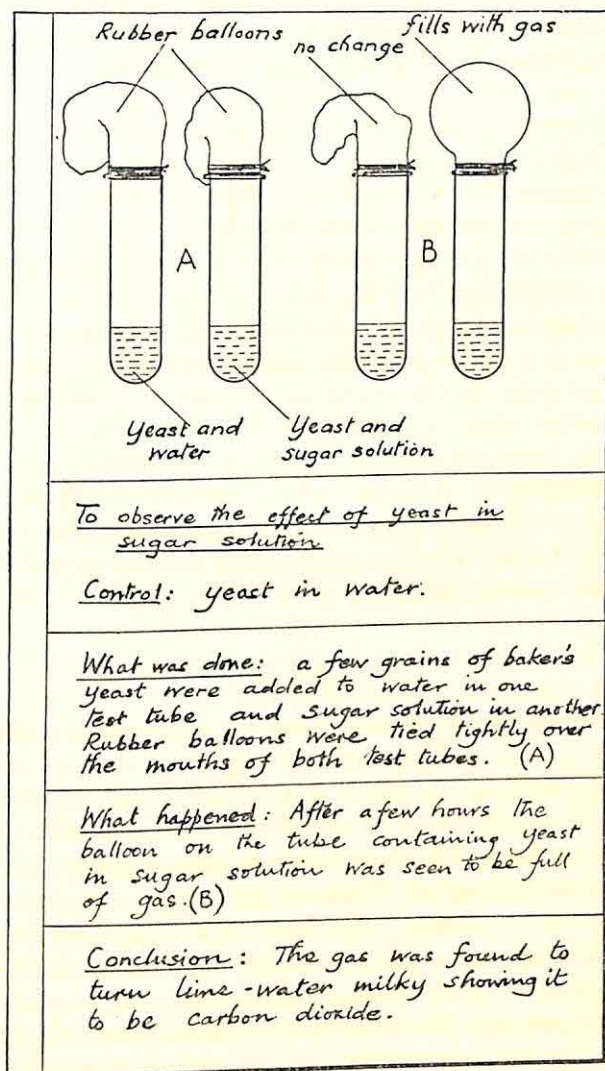


FIGURE 12. Recording a demonstration

blackboard, it is repeated, can have but a limited value in these lessons, as the aim is not to compile a notebook full of arbitrary facts, but to enable children to work things out for themselves; and the

pupil work stage is important for this purpose. It may be mentioned here that another valuable activity for older pupils is the compiling of a glossary of scientific words. They should have special notebooks for this purpose, and if teachers give accurate definitions, this may be an occasion when copying from the blackboard is permissible. During this stage of the lesson it is frequently necessary for the teacher to move about the classroom, from one group of pupils to the next, inspecting their progress and discussing their difficulties.

STAGE 4: The conclusion stage. This short part of the lesson is not always essential, the work often finishing after the pupils have recorded their observations. On occasions, however, it will be helpful to repeat again the principal points of the lesson, so that they remain clear in the pupils' minds at the end.

Teachers may find that these methods of teaching which encourage the children to use their own initiative in learning are, at first, more difficult to organize and less fruitful apparently, in immediate results, than the older methods of instruction involving copying from the blackboard, repeating in unison, learning by memory, and so on. Nevertheless, they must realize that education is only of value if it is meaningful to the pupil, spontaneous and active and happy. As time goes on the value of these methods which develop pupils' initiative will become increasingly clear.

SPECIMEN LESSONS

A. The first example in lesson planning is for the general topic 'Insect life in the garden', such as might be prepared for small children in the first or second year at school. It is concerned with the observation of certain kinds of insects commonly found in a garden. It will be noted that, however informal the lesson may be in fact, it must still have form, and a structure with underlying stages, the mark of which is that they always denote a definite change of pupil activity.

Starting the lesson as usual in the classroom, the teacher would use large diagrams of (a) an aphid, and (b) a black ant, to introduce the children to certain fundamental differences between these two kinds of insects. By means of simple questions the main features of body structure, particularly of the mouth parts, would be brought out, and the diagrams labelled.

Going out-of-doors to a place in the garden where aphids and black ants have been seen together, pupils will watch their behaviour. What are the insects doing on the plant? What is the effect on the

plant? What is the relationship between the ants and the aphids? How are the ants feeding?

Collect some of the insects by breaking off a shoot of the plant on which the aphids are feeding.

Returning to the classroom, or sitting under the shade of a tree, pupils may then be given coloured modelling clay with which to make large models of these insects. Whilst this stage of the lesson is going on, the teacher will talk again with the children, bringing out the ideas of the lesson which are (i) that aphids suck the juices of plants causing them to become weak: (ii) that black ants take juices from the bodies of the aphids, and (iii) some insects are therefore enemies of a gardener.

B. The second specimen lesson is for pupils in one of the two middle years of the primary school course. The topic is 'Garden tools'.

Lesson aim: To compare certain digging tools as aids for making work easier.

Reference: *The Teaching of Rural Science in Tropical Primary Schools*, page 97.

Equipment: Garden spades and draw hoes (one of each between each pair of pupils): simple apparatus to demonstrate the lever principle.

STAGE 1: Indoors, question the class:

What is work? Use simple demonstrations to bring out the point that when work is done, movement is involved. What are tools? Discuss the meaning of the word (avoid the use of the word 'machine' at this stage, if possible). Summarize the pupils' answers where relevant on the blackboard, so as to lead to the question:

How are digging tools able to make work easier?

STAGE 2: Indoors, demonstrate the lever principle by using a ruler as a crowbar, resting on a pencil to lift the edge of a book. Refer to the fulcrum as the position where no movement takes place. Compare the amount of movement at the point where the work is done, with the movement where the force is applied.

Using the blackboard, compare a garden spade and a draw hoe as examples of tools based on the lever idea. Mark on each diagram (i) where the force is applied; (ii) where the work is done; (iii) the position of the fulcrum.

STAGE 3: Out-of-doors, pupils to practise using the tools so as to get most work done efficiently without wasting energy. Question:

Where is the best position to hold the handle?

In which direction must the force be applied to move the soil?

STAGE 4: Indoors, pupils to name examples of other garden tools

which depend on the lever principle. Revise by questions the main ideas of the lesson.

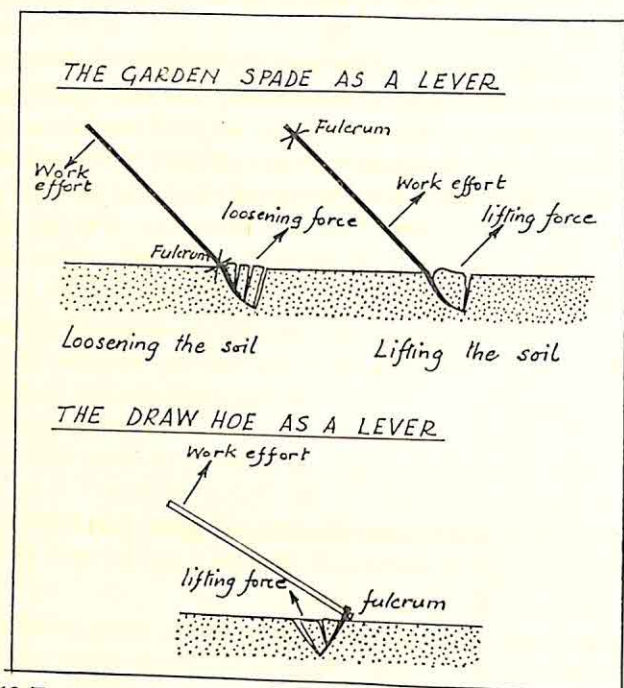


FIGURE 13. Example of blackboard work to accompany the lesson on garden tools

C. The third specimen lesson, for pupils in one of the two upper years of the school, is on the topic 'Farm records'. It would follow a visit to a farm where there were milking cattle, the daily yields of which are recorded.

Lesson aim: To demonstrate the value of milk records.

Reference: *The Teaching of Rural Science in Tropical Primary Schools*, page 167.

Equipment: Milk records of a high-yielding and a low-yielding cow.

STAGE 1: Revise the background facts of milk production by questions to the class, such as:

- (i) Are all cows able to give milk?
- (ii) For what purpose does a cow produce milk?
- (iii) How does a farmer ensure a regular supply of milk?

Summarize the answers on the blackboard as follows:

A cow cannot give milk until it has produced a calf. As a result of careful breeding, cows are able to give much more milk than is required

by one calf. By careful feeding and efficient milking, cows may go on producing milk for many months.

STAGE 2: Using the milk records acquired on a previous farm visit, or supplied by an agricultural officer:

- (i) Draw a graph on the blackboard of the monthly quantities of milk produced by a low-yielding cow.
- (ii) Teach the meaning of words such as in-calf; gestation; lactation; drying-off; steaming-up; by outlining the progress of a cow through a milking year.

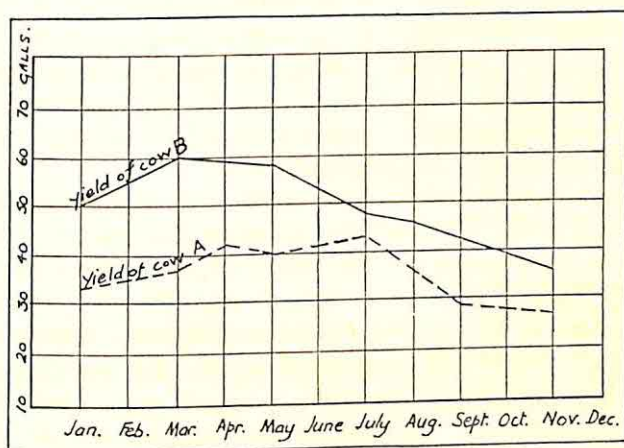


FIGURE 14. Example of blackboard work for the lesson on milk records

- (iii) Discuss the pattern of the graph. Why is it high at certain times of the year? Is more milk produced by the cow at the beginning or the end of the lactation?

STAGE 3: Using the same figures as in stage 2, pupils will draw the graph in their notebooks, then will calculate (a) the average daily yields at different points through the lactation; (b) the total yield for the whole lactation.

Using figures related to the production of a high-yielding cow, pupils will now superimpose a second graph over the first, using a different kind of line for distinction. The lactations of the two cows may then be compared by means of written sentences.

STAGE 4: Conclude the lesson by emphasizing the main points which pupils have outlined in their notes.

PLANNING PROJECTS

The advantages of the project approach are many. It allows the chance of self-initiated work on the part of individual pupils, whilst at the same time permitting co-operation. It encourages a scientific approach to the solution of problems through observation, experiment and the keeping of records. It allows correlation with other subjects, and the exercise of the imagination through the inclusion of various art and craft activities. As the responsibility for learning

PROJECT TASK CARD 4	
	FARM PLANTS
	Questions to answer -
1.	Are any plants grown as food for livestock?
2.	Which plants yield produce to be sold?
3.	Is there a rotation of crops?
4.	Is grass part of a rotation on the farm?
5.	Are there any trees to be seen?
6.	What is the effect of the trees on grass?
7.	How are weeds kept under control?
8.	What methods are used to harvest the farm crops?

FIGURE 15. A project work task card

is put on to the pupils, it is valuable as a means of acquiring self-reliance. It is the teacher's task, however, to create the right conditions and atmosphere in which these processes can take place.

In practice, there are a number of ways in which this can be done. One method of organizing the project work proposed in Part Two, is to give groups of children different aspects of a topic to work at, on their own, within the teacher's overall plan. At the end of the allotted time, a method of presentation of the pupils' work must be chosen which will suitably link the various aspects of the project together, and allow all to benefit from the results of each other's study. It will

be appreciated that careful planning is essential if the work is not to become purposeless. A number of periods will, of course, be required for each project scheme. It will be found useful to hold a general discussion lesson at the beginning by way of introduction, to decide how the pupils are to be divided up for the work, and to make sure that everyone knows what they are about to do, and to give them a chance to develop interest in the idea. Each group, at least, should be provided with project work notebooks, but it is preferable that each pupil should have his own. The best way to get the groups started is to write down the tasks in the form of a set of 'questions to be answered' on work cards (see Fig. 5). As the project proceeds and interest grows, the more formal kind of classroom lesson may cease; but there will nevertheless be many opportunities for sound teaching,

as new questions arise, and as pupils come up against problems which they cannot answer with their existing knowledge.

PREPARING ASSIGNMENT WORK

In many parts of the world enterprising teachers have made good use of the assignment system with older pupils. It is not only a method suitable for particular topics within any one subject, but is one in which many broad aspects of knowledge can be incorporated. As far as the upper forms of tropical primary schools are concerned, it will be necessary at first to limit assignments to a few suitable topics in rural science as a variation from more formal kinds of teaching.

At the outset, the teacher prepares 'work cards' on which are written 'things to do' or 'problems to solve', rather as for projects (see Figure 15). But each pupil then proceeds at his own time and in his own way to work through the whole set of assignments. The classroom becomes more like a workroom, and the teacher an adviser and a provider of materials and aids, rather than an instructor. From time to time, it may be necessary for pupils tackling similar problems to be grouped together for lesson work; but generally, individual teaching and guidance will be much more in evidence. Pupil activity through this approach in science subjects, comes close to that of the scientific research worker, and because of this it is a thoroughly sound method to adopt. Although it is a technique which has been little used in the past in tropical schools, to master it is worth considerable effort on the part of an enthusiastic teacher.

REVISION AND TESTING

The aim of revision should be to increase understanding so that when testing time comes, whatever form the questions may take, an intelligent attempt may be made to answer them. There will be no place for the meaningless repetition of sets of facts learnt off by heart, remembering that this subject is largely practical, being based firmly on a foundation of observation and experiment.

The most important general method of revision is to make use of the fact that schemes of work may be planned concentrically. Not only within a series of lessons, but also from term to term and from year to year, the same topics recur at progressive stages of difficulty, and from different angles. In Part Two of this book it will be seen that this approach has been adopted to a large extent. As each group of

lessons is begun on each of the various major topics within the subject, the opportunity will be there to revise what has gone before, and to recall the practical activities which were done. A frequent back reference to ideas previously stressed, therefore, is the most certain method of revision.

Another possibility is to include in a scheme of work definite lessons set aside specifically for revision. These might well be after each set of lessons, project or assignment. It is often the custom to begin lessons with a brief revision of the previous one; but this is seldom satisfactory unless it is a deliberate continuation of a lesson left unfinished. There is, of course, a very suitable place for revision at the end of a lesson; if time is available, a recapitulation stage can be included.

A common method of testing is to set questions from past examination papers, but this is often dull and unrelated to the pupils' interests. A more enterprising method of achieving the same end is to prepare 'quiz cards': which is in reality a method of revision and testing together. The example shows such a card prepared for pupils who have been studying the topic 'Garden rotations'.

QUIZ CARD 2 - ROTATIONS	
1	What different kinds of crops are grown in the school garden?
2	In what order do they follow each other round the plots?
3	Are any plants grown on the same plots season after season?
4	Which plants do you think are the heaviest feeders?
5	Why are BEANS thought to be a useful crop to include in a rotation?
6	Give an example of a 'cleaning crop'.

FIGURE 16. A specimen quiz card

All that pupils will require is a notebook and pencil or pen. They will need to be asked not to write on the cards, as others must use them later on. They will be told to think hard all the time they are working, about what they have been doing in previous lessons. They must try to remember the observations they have made, and to work accurately rather than rapidly.

If a pupil does not know an answer, he will not be given it, but will be told how to find it out for himself. Above all, it must be made clear that pupils are to enjoy themselves at their work, and that they will only be checked if they are inaccurate.

In order to check accuracy, the teacher will need to prepare answer cards to the questions. These may be given out to the pupils, so that they can learn how to check their own work. There should never be too many questions on each card: perhaps ten or twelve would be a

maximum. The questions should be worded with care, so that the answers may be written down in short form, as this is a method of testing knowledge of facts, not the ability to express complex ideas.

There is another useful way of assessment which can be introduced. It deals with actual objects, and is therefore a practical activity at the same time as a test, and this will give added interest for the pupils. It has the advantage, furthermore, that both theory and practical knowledge can be tested merely by changing the mode of organization of the test. For example, to test theory, objects related to selected aspects of the subject, such as 'vegetative propagation', are collected together in the classroom, and the teacher prepares questions related to them. He asks the questions orally whilst holding up the relevant object, and each pupil writes down the answers in order, for future correction:

1. Holding up a dibber, the teacher asks for an explanation of the method of propagation with which it is used.
2. A cutting may be compared with a sucker, by means of questions on these two kinds of vegetative parts.
3. Displaying a pair of pruning shears, pupils are asked to describe diagrammatically the mechanical principle involved in their use.

To test practical knowledge, objects related to the various aspects of the subject are collected together at a number of separate 'stations' spaced around the school garden, some distance apart. At each, a teacher is placed with a set of questions as before, but related to the practical application of the objects. For example, with the same questions as above, pupils may be asked to demonstrate the use of the dibber, to actually take a cutting from a parent plant, or to demonstrate the most efficient method of handling the pruning shears so as to get the best mechanical advantage. Although with this method a number of teachers will be concerned at the same time (and this may mean some rearrangement of lessons with other classes), it is simpler in that there is no marking of written papers afterwards.

If each topic in rural science is revised, and pupils are tested in interesting ways such as those suggested above, they will feel a progressive sense of achievement, and they need have no fear that their knowledge will be inadequate, when the time comes for their end-of-school examinations. Real experience will have fostered imagination and enthusiasm all the time, and a true understanding of the environment will be the reward.

PART TWO

Planning Schemes of Work

Educational authorities in each country or region will have prepared an outline syllabus for the subject; and this may include topics listed year by year, text references and suggested times to spend on each. It must be the responsibility of the teachers themselves, however, to plan their own schemes of work. These will vary from place to place according to local conditions, time available, and the teacher's own interests, and to this extent the syllabus may be modified. It is hoped that the suggestions contained in this part of the book will be useful for planning schemes of work as well as actual lessons themselves.

A scheme of work is a lesson-by-lesson programme planned for each week of each term and it is emphasized that the material which follows is not intended to be used as a scheme of work as it is too comprehensive. It would be unlikely that any school could include all that is suggested here; and in any case, a scheme of work would need to include material related to topics in general science and nature study, as already mentioned in the preface. It is for these reasons that no attempt has been made to suggest how much time should be spent on each section or in what order they should be taught.

It will be seen that the subject matter has been arranged under six headings, corresponding to the main divisions of the subject. In order to ensure that the work at any stage will be suited to the abilities of the children, the material in each of these six sections is further subdivided to agree with the three stages of child development considered previously. The whole of it covers a possible six years, the last six years of the primary course however long the primary course lasts. The material, therefore, is arranged concentrically and is repetitive: a method which, as has been said, will bring about real understanding, and is valuable for the purpose of revision.

Although it is topics which are listed in the outline, teachers are reminded that what they should be attempting to bring out are the essential *ideas* related to the topics. Of course, before planning any lesson in detail, we must have clear in our minds exactly what we intend to teach. To give guidance in this respect, the essential 'Main

Ideas' of each topic are listed at the beginning of each section; and these precede detailed notes on how they may be brought out in the lesson work and the various kinds of practical activities.

OUTLINE OF SUBJECT MATTER FOR A SIX-YEAR COURSE IN RURAL SCIENCE

A. TOPICS CONCERNING THE SOIL

<i>First and Second years</i>	What soil is Living things in the soil Caring for the soil
<i>Third and Fourth years</i>	Decay and soil fertility Conserving soil moistures Garden tools
<i>Fifth and Sixth years</i>	Erosion and soil conservation Digging and soil cultivation Manures and fertilizers

B. TOPICS CONCERNING GARDEN PLANTS

<i>First and Second years</i>	Naming garden plants Different ways plants grow New plants from old
<i>Third and Fourth years</i>	Seed sowing and transplanting Seed selection and storage After-care of growing plants
<i>Fifth and Sixth years</i>	The variety of garden plants to grow Vegetative propagation Caring for trees and shrubs

C. TOPICS CONCERNING FOOD PLANTS

<i>First and Second years</i>	Plants to eat Plants to avoid Small animal life in a garden
<i>Third and Fourth years</i>	Local vegetable crops Harvesting food plants Weed plants of a garden
<i>Fifth and Sixth years</i>	Different kinds of fruit crops Diseases of garden plants Control of insect pests

D. TOPICS CONCERNING FARMS AND FARMING

<i>First and Second years</i>	What a farm is Different kinds of farms A farmer's work
<i>Third and Fourth years</i>	A local farm study Farm buildings and equipment Farm craftsmanship
<i>Fifth and Sixth years</i>	Farm management Farm planning Rural land use

E. TOPICS CONCERNING FARM CROPS

<i>First and Second years</i>	What a grass plant is Grass as food for animals Other farm plants
<i>Third and Fourth years</i>	Useful grasses Weeds of grassland Caring for grassland
<i>Fifth and Sixth years</i>	Crops for sale off the farm Fodder crops for livestock Feeding farm animals

F. TOPICS CONCERNING FARM ANIMALS

<i>First and Second years</i>	Animals as pets Recognizing farm animals Wild birds and mammals in a garden
<i>Third and Fourth years</i>	Care of small livestock: chicks Facts about farm livestock Wild life on a farm
<i>Fifth and Sixth years</i>	Calf rearing Animal health and hygiene Livestock improvement

Material for the First and Second Year Lessons

A. THE SOIL

Main ideas to be brought out

- (1) Soil is found nearly everywhere on the earth's land surface.
- (2) Soil is made up of tiny pieces of rock and the remains of living things.
- (3) Water and air are both present in the soil.
- (4) Many animals live in the soil; most of them are too small to be seen.
- (5) Plants grow rooted in the soil.
- (6) It is necessary to care for garden soil because it is the home of cultivated plants.
- (7) Tools are used to help care for the soil.

(1) to (3): What soil is

The approach should be quite informal. Simple discussions and talks may be held either indoors, or outside in the garden. Whilst on nature walks, a teacher may ask the pupils questions which will encourage observations from which the answers may result, and prompt in turn more questions. The problem 'How has soil come about?' might be answered by the examination of a nearby earth bank, where underlying layers of soil and rock are exposed. The realization that garden soil is not 'dirt' is another important conclusion that the teacher of rural science should endeavour to arrive at, with the children, during these early studies of the soil, as pupils will first get to know about soil by handling it. They should be given opportunities to handle and examine different kinds of soil, if possible. Samples could be collected from a river bed, a woodland, and a sandbank. As well as the texture of the soil, its weight, temperature and moisture content can be experienced in similar ways. Gradually the 'feel' of what is a good garden soil (a loam), and equally important, what a poor soil is like, can become known to the children.

Practical work

- a. Using various sized tins or other containers, encourage children to make 'mud pies', experimenting with soils of different composition.

The effect of water in soils can be experienced by this play method: much water turns a clay soil smooth and slimy, whilst a sand soil remains gritty. With a small amount of water a clay soil may become pliable, though a sand soil will never do so.

b. Shake up some two or three handfuls of soil in a tall jar which is about half full of water and watch the remains of plant material float to the surface. Where has this plant material come from?

c. Search the soil for the remains of animals, e.g. skulls, teeth, beetles' wings, small bones, feathers, etc. Group them on the nature table.

d. Place dry soil in a container, pour water over it and watch the bubbles of air rise from the soil to the surface of the water. Try the same experiment with a lump of moist clay. Discuss the importance of air in the soil from the point of view of living things.

e. Make collections of small stones from the soil. Let the pupils grade them according to size, colour or shape (some will be sharp and angular, others will be smooth and round, for example), and so introduce the idea of classification. Other characteristics of stones to note are their smoothness (of quartz, for example), or their roughness (of sandstone, for example). The heaviness (e.g. of basalt) and the lightness (e.g. of pumice) may also be compared, if suitable specimens can be found.

(4) and (5): Living things in the soil

This section continues naturally from the previous one. At this early stage, no mention need be made of the microscopic life in soil, although so important. The main fact to stress is the abundance of living things which inhabit the soil, and that they are of so many different kinds. Introduce the idea that some animals in the soil are harmful to plants, by drawing attention to their visible effects. Examples to watch are such insects as termites, cutworms, small beetles, etc., and mammals such as moles.

Practical work

a. Take soil samples from selected areas of the school grounds and count the number of living things to be found in them. Try to group them first as plants or animals, and then in smaller, more precise groupings. Seeds, roots, spiders' eggs, insect larvae, worms, may all be found.

b. Show pupils a bean seed germinating in damp sawdust, and point out the tap-root. Talk about its use to the plant in the soil. What

other purpose do roots have besides taking in moisture? Are there any plants without roots? Are all plants with roots fixed in the soil? c. Collect plants with different kinds of roots, e.g. a grass plant, a carrot, a bean. In what ways are their roots different?

d. Sow some seeds at the same time, on the same day, in soils of very different quality. Later compare the results and talk about what you see. Try to keep a simple record of the development of the seedlings from day to day by pupils making drawings of them on a nature calendar.

e. Collections of living insects found in the soil will provide material

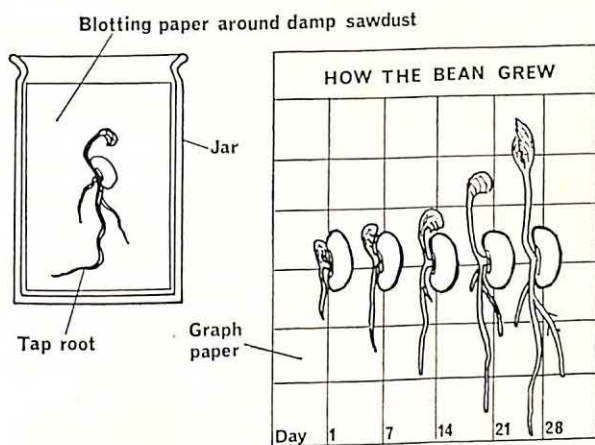


FIGURE 17. Germination of a bean seed and a method of recording its growth

for much interesting work related to nature study. At this time, however, the idea is to stress the relationship between the insect and the environment in which it was found. Are the insects feeding in the soil, laying their eggs in it, or seeking shelter? Collect insects from soils which differ considerably, such as soil from forest, plain or marsh.

f. Observe the traces of larger animals in the soil, such as the earth-mounds made by moles, or the holes dug by porcupines, ant-bears, etc. Try to decide where the animals are moving and on what they are feeding. Make a clay or paper model of the garden for pupils to mark on where these larger animals are seen. Let pupils make drawings, or clay models, of what they think these animals look like.

(6) and (7): *Caring for the soil*

Plants make their home in the soil; as animals, including ourselves, are dependent on plants for food and other needs, it is therefore

essential that we care for the soil properly. In discussions, try to bring out this idea by asking children questions concerning the use of plants by human beings, such as 'What substances obtained from plants are used for making clothes?'

If plants are to grow properly, the soil must be kept moist, fertile and cultivated. Have a talk on this and consider how it might be done.

Introduce the idea of the school garden as a playground, as well as a workshop, and that beautiful flowers help to make the garden more pleasant to play and work in. Most children take great delight in sowing seeds in their own small plots and watching the seedlings come above ground, but there will be many an opportunity to point out that they will not do so unless the soil is cared for. This will be the occasion for indicating the importance of hoeing and weeding, also, even at this early stage.

Towards the end of the work on this section, a discussion may be held on the idea that soil is nearly everywhere on the earth's land surface. A collection of pictures from other parts of the world can do much to increase interest in this: pictures which show desert and polar regions, forest land, mountain and grassland. The question, 'Why are there few plants in polar or desert lands?' will bring in the important geographical idea that the one is too cold and the other too hot; and will then lead on to the idea that fertile soil will only be found where wild plants have been growing for many years. Such general observations and indications will prepare the way in children's minds for a realization of the importance of humus in the soil, to be taught in later school years.

Practical work

- a. Leave a small plot completely alone after sowing some seeds in it and compare the results with those in the children's plots which they are cultivating. Where have the weeds come from?
- b. In wet weather, take the children to see the colour of the water in a stream or river and draw their attention to the quantity of soil it contains and is carrying away with it. After collecting some in a jar, allow it to settle on the nature table, and observe the soil particles. Why is soil being carried away in this manner? Where is it coming from? What has happened to the plants that were growing in it?
- c. During the dry season, water some growing plants. Compare the effect of watering from the point of view of rate of growth, size and

healthiness, and time of flowering, with other plants grown at the same time without being given any water.

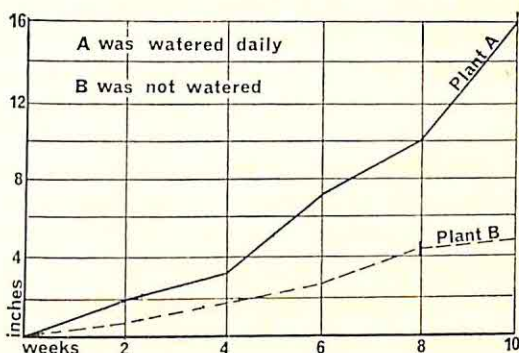


FIGURE 18. Graph comparing the effect of water on growth rates of plants

d. Demonstrate the advantages of using tools for certain garden tasks. Use only small hand tools, such as trowels, rakes, etc., but indicate that with their help, work is made easier, yet done better, than without them.

B. GARDEN PLANTS

Main ideas to be brought out

- (1) Garden plants are of many sizes and have different forms.
- (2) Garden plants all have names and we can learn to recognize them.
- (3) Some plants remain soft and green; others make wood.
- (4) Some plants are short-lived; others last for many seasons.
- (5) Some plants are not wanted and are called weeds.
- (6) New plants may be obtained by planting parts of a parent plant, or by splitting up its roots.
- (7) Most garden plants produce flowers, many of these are brightly coloured and have a sweet scent.
- (8) Flowers produce fruit; inside the fruit are the seeds.
- (9) Seeds grow into new plants when put in fertile soil.

(1) and (2): Naming garden plants

All small children love picking flowers in a garden, and this activity may form the basis of the method of study for this section of the work. The aim should be to use children's natural interest in the colour, form, size and scent of the flowers to familiarize them with

their most obvious characteristics. Any collections that are made should be classified according to these general characteristics, at this stage, rather than by any more scientific system. In addition, the shape of the leaves, the height of the plants and their general habit of growth should be observed, so that pupils may learn to recognize the plants even when they are not actually in flower. Leaves, for example, often have a very distinct texture, and this should be experienced. Pupils may therefore be encouraged to pick and play with leaves, taking care, of course, to avoid those which may have stinging hairs on their surface. Children should be careful never to damage or destroy plants unnecessarily during these activities.

If the formal names of the plants in the garden are not known, it is possible to invent suitable names for them. These should have some easily remembered connexion with the appearance, or other characteristic, of the plant, just as we have the name Sunflower for *Helianthus* (from the shape and colour of the flower-head), and Camel's-foot plant for *Bauhinia* (from the shape of the leaves).

A classroom can be made more pleasant to live in if flowers which pupils collect are put in vases or jars of water on the nature table. If children are given the task of changing the water daily, they will learn that this substance is essential to plants after they have been picked, if they are to remain alive and fresh for any length of time.

A keen teacher of rural science will do all he can to see that supplies of flowers are available in the garden of a school; this will mean sowing seeds, or propagating plants by other methods, from time to time, so that blooms will be there when wanted.

Practical work

a. In the garden, each child may be given a small plot, which need not be more than six feet square, in which to grow seeds. These should be of easily cared-for plants, whose shoots appear above the surface of the soil quickly, which are strong and robust, and which produce attractive flowers. Examples are various kinds of annuals, such as Nasturtium (*Tropaeolum*), Love-in-a-mist (*Nigella*) and Marigold (*Calendula*). From this activity children will learn much about plants and gardening processes, such as the need to keep growing plants free from weeds, shaded from too much sun, and watered when dry.

b. To make a collection of tree leaves is a rewarding activity. They may be collected on nature walks, and later pressed between the pages of a large book. After drying, the children may fix them into

individual, home-made 'scrap-books', by means of small pieces of gummed paper. Leaves should be chosen for their varied and interesting shapes; and suitable examples are those of Castor oil plant (*Ricinus*), Passion-flower (*Passiflora*) and Tree-tomato (*Cyphomandra*). Drawings of leaves or leaf prints may be the basis of pattern designs for the cover of the scrap-books.

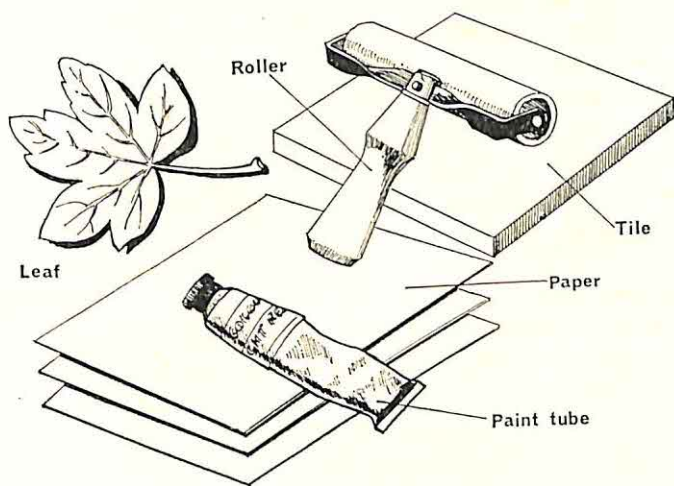


FIGURE 19. Equipment used for making leaf prints

c. Make collections of garden weeds and press them between pieces of newspaper under a weight, as an alternative method to that used for pressing leaves. Many specimens may be pressed at a time, using a number of layers of the paper. It is essential that they are properly dried before being mounted on pieces of white paper. Always write alongside pressed plants, where the specimen was found, its name (if known), who found it, the date and any other useful information.

d. The most instructive activity which children can do, in relation to this section, is to make drawings of garden plants and their parts. These should always be made from actual specimens and, if possible, there should be coloured crayons available for the pupils to use. Much will be learnt about the different forms of plants; nevertheless it is the act of making the drawing that is important, whatever child-like mode of expression results, rather than the production of detailed diagrams of the specimens. Teachers should insist, however, on general accuracy, such as whether the leaves are placed opposite or alternate on the stem; or whether petals are shown as being joined or separate from each other.

(3) to (5): *Different ways plants grow*

The object of this section is to get a first idea of the variety of growth habits of plants. Introduce it through simple classification again, observing that all garden plants may be grouped as either soft-stemmed plants called herbs, small woody plants called shrubs, or larger plants with wood called trees. At this stage, only the general growth habits need to be noted, and these can be related to the lesson work on the recognition and naming of flowers, as outlined in the previous section. The manner in which the inner growing part of woody plants, containing the sap, is protected by the bark around it, may be noted; also that trees may be seen sometimes without their leaves (e.g. *Erythrina*) and that some soft-stemmed plants die down, only to appear again the following growing season (e.g. *Gloriosa*, *Amaryllis*, *Zephyranthes*).

Practical work

a. If children do not spend much time at their plots after sowing seeds in them, they will soon become aware that many wild plants which are not wanted grow in a garden. Make a collection of herbaceous plants which are common weeds. Discuss the characteristics which make these plants so persistent; for example, long roots, many seeds, efficient dispersal and quick growth.

CHARACTERISTICS OF COMMON WEEDS				
Name	Growth rate	Root form	Seed No.	How spread
Lantana weed	Rapid	Woody & persistent (in juicy fruit)	Numerous	Seeds by birds Root and stem propagation
Oxalis	Rapid	Small tubers	Numerous	Production of numerous root tubers
Couch grass	Rapid	Very long runners	Numerous	Wind blown seeds. Deep spreading roots

FIGURE 20. Recording the characteristics of weeds

b. Make a nature calendar and insert on it information related to the times of the year when trees are in flower and in leaf. Note those tree plants which (i) flower when the leaves are absent (ii) flower when in full leaf (iii) are rarely seen to flower at all. (Figure 21).

c. Make observations of bamboo, palms and conifers. What are the chief characteristics of these plants? For example, examine the stem

structure of the bamboo; note the fibres in the leaves of palms; collect cones. Do conifers shed their leaves?

d. Compare the growth habits of climbing and creeping plants, by seeking those which have thorns, suckers, tendrils, twisting stems, etc. Note especially where these plants are generally found.

e. Keep watch when out-of-doors for a specimen of the 'sensitive

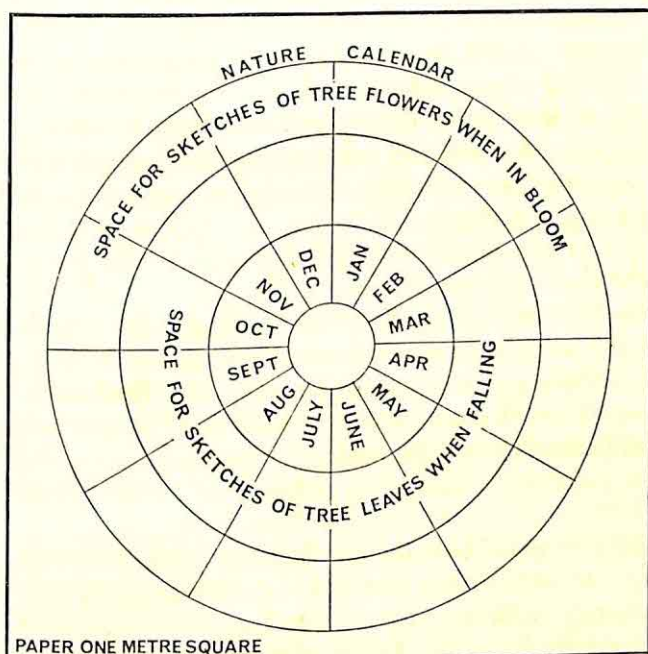


FIGURE 21. A pattern for a nature calendar

plant' (*Mimosa*) and transplant it to the garden. Encourage children to touch it and watch the leaves 'close up'. Under what natural conditions do the leaves close up?

f. If a stream is available nearby, observe the plants which grow in it. How are they adapted to survive with many of their parts under water? How does air get to the roots?

(6) to (9): New plants from old

The observations and practical work completed already in connexion with the various kinds of plants will have suggested the idea that the underground parts can give rise to a generation of new plants again. This is too early a stage to attempt a classification of different kinds

of underground perennating organs of plants; but the fact that food substances are stored away by the plant in the root parts may be realized by referring to root plants commonly cultivated for human consumption, for example, the carrot or the sweet potato. The fact that the plant food stored away will be utilized to make new stems, flowers and other parts, in subsequent seasons, or will provide nutriment for young shoots before the leaves are fully formed, may then be taught.

It will be appreciated already that it is the flowers of plants which produce the seeds from which new plants may be grown. Observations on the wide variety of colours in flowers will introduce the idea of insect pollination, and will lead to the conclusion that it is the brightly coloured ones which are attractive to insects. The fact that not all plants are pollinated by insects, however, may be learnt by recording over a period of time which flowers insects do visit and which they commonly leave alone.

The idea that a 'fruit' is the name of the part of a plant which contains the seeds, and is not just something nice to eat, can be brought out as a result of examining fruits with hard cases, which contain easily visible seeds, such as those of the Flame tree (*Spathodea*), or the blue-flowered *Jacaranda*.

Practical work

a. Dig up clumps of herbaceous plants, such as Barberton daisy (*Gerbera*), and demonstrate that many new plants can be made from the old ones by splitting up the roots and replanting them in different children's plots. Demonstrate the best way of doing this without damaging the roots.

b. During the resting season, dig up bulbous-rooted plants and observe how they have formed new bulbs alongside the old ones whilst in the soil. Separate and replant the bulbs, marking the positions with wooden stakes. What becomes of the old bulbs if left in the soil?

c. Cut open the thickened root tubers of a plant, such as a *Dahlia*, and notice that it contains much stored food material. Place one in the soil in a position where it can be easily dug up again, and after a few weeks observe the formation of new shoots.

d. Put an onion bulb at the top of a glass jar full of water and keep under observation on the nature table. Watch the growth of leaves and roots. Similarly, fill a flat tin or earthenware pan (with holes in the bottom for drainage) with soil, and place a few carrot tops on the

surface. Cover with small stones and water gently. In course of time, shoots will appear, making a 'miniature garden'.

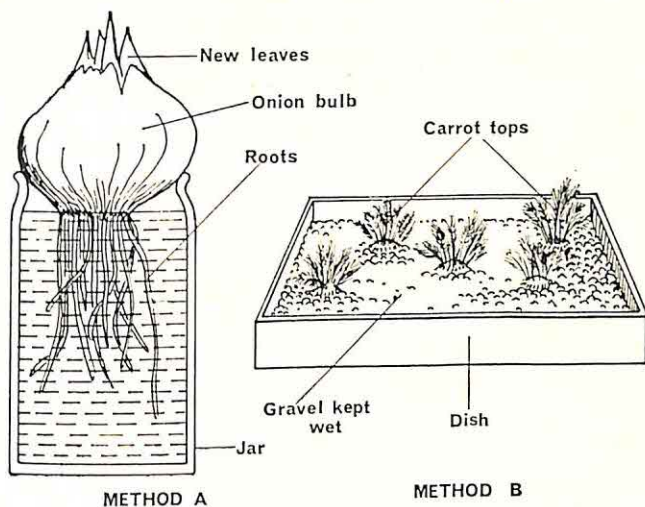


FIGURE 22. Growing plants in water

e. Out-of-doors, try to find large insects, such as bees, sucking nectar and carrying pollen on their legs and bodies. How are the flowers they visit adapted to receive the insect? Let children taste the nectar produced by various flowers (e.g. *Fuchsia*). Where on the flower is the nectar generally found?

f. Discover if any of the flowers in the school garden are wind-pollinated. If so, discuss how these plants differ from those visited by insects. Observe particularly the lack of petal colour and even of petals themselves, sometimes; the length of the stamens; the great quantity of pollen that is produced; and the loose hanging growth of the flowers in general.

g. Make a collection of the fruits of garden plants, together with their seeds. Children may mount these in the form of a display for the nature table, grouped according to size. Stress that as well as a tiny plant, seeds contain food for growth. This may be observed by soaking the seeds of a leguminous plant, such as a bean, in water, and then allowing them to germinate on moist cloth for a day or two.

h. Produce seedlings from as wide a variety of small seeds as may be collected by means of the 'rag doll' method. Alternatively, the seeds may be placed on the outside of blotting paper placed around the inside of a wide glass jar filled with moist saw-dust or moss. Does the

root or the shoot appear out of the seed-case first? Germinating seeds is an activity which may be repeated with benefit at intervals during the years.

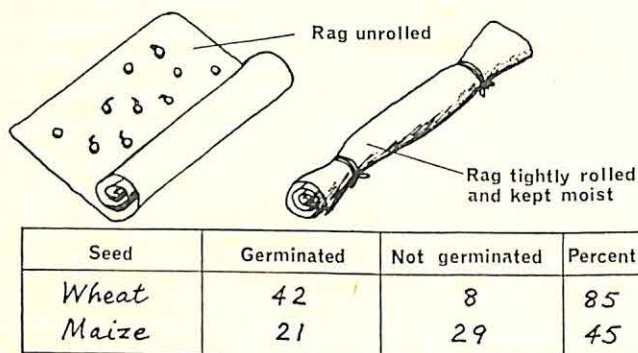


FIGURE 23. Testing seed germination by the rag-doll method

i. Use the nature calendar to record the first appearance of seedlings of garden plants as they come above the ground. (Figure 21.)

C. FOOD PLANTS

Main ideas to be brought out

- (1) Many plants are good to eat; we may eat the leaves, roots, stems, fruits or seeds of plants.
- (2) Fruits may be soft or juicy; some are sour to taste, others are sweet.
- (3) Some hard kinds of fruit are called nuts.
- (4) Some plants provide medicines.
- (5) Certain plants are poisonous and should not be eaten.
- (6) Food plants in a garden are attacked by many insects; some garden insects do no harm to plants.
- (7) Insects are found on plants, in rubbish, in the soil and in the air.
- (8) Many plants are visited by insects seeking nectar; in doing so they help pollination.
- (9) In the soil, small animals such as slugs and snails, may be found.

(1) to (4): Plants to eat

Although it will not be feasible for pupils to cultivate many food plants at this stage, they will become familiar with the appearance of some of them by visiting the demonstration garden plots in the main

school grounds, and observing the vegetable plants and fruit trees which are cared for by older pupils. There are some varieties which they might attempt to cultivate themselves, however, and these will include quick-growing plants, such as lettuce, spinach and okra, various roots like carrot, beet, etc., ground-nuts, onions, and radishes (for picking whilst small and not too strong in taste), legumes such as peas and beans, one or two kinds of fruits, such as melons or the egg plant, and some spices.

Practical work

- a. Using pictures to be found on the seed packets, classify locally-grown vegetable plants simply, according to whether they are (i) leaf crops, (ii) root crops, (iii) grain crops, etc. Paste each group of pictures on to large sheets of white paper to make wall charts.
- b. Children may be encouraged to taste common fruits to find out which are acid or sour, and which are sweet. Why are ripe fruits often sweeter than unripe ones?
- c. Cut open an orange or other citrus fruit, in order to find out where the seeds are growing. Do the same with a stone-fruit, such as loquat or mango. Where is the sweetest juice to be found in such fruits?
- d. If nut trees are available to study, try to find out which part of a nut is the seed.
- e. Taste raw the roots of plants such as carrots, yams or sweet potatoes so as to discover whether they are 'sugary' or 'starchy'.
- f. Many local plants are considered to have medicinal properties. Find out, by enquiry made in the neighbourhood, which these plants are and collect the relevant part. Examples are the rind of the pomegranate (*Punica*) which is said to stop bleeding, peppermint (*Mentha*), claimed to cure stomach pains, and the bark of certain *Cassia* trees, thought to have a soothing effect on stiffness in the joints of limbs.

(5): *Plants to avoid*

In all districts there are plants known to be poisonous, and it should be part of a teacher's work to instruct children at an early age as to which plants to avoid. Local knowledge should be acquired again in this respect. Sometimes it is only a part of the plant which is poisonous. An example is the cashew nut (*Anacardium*): the two layers of the skin of the nut, wherein is contained a poisonous oil, have to be removed before eating. The fleshy part inside is nevertheless very sweet.

Practical work

a. The best way for children to get to know poisonous plants is to have their attention drawn to them whilst out on nature walks, explanation being made at the time about the harmful parts. This is obviously not a topic which can be studied experimentally! The parts to avoid may be observed, however, such as the large fruit of the thornapple (*Datura stramonium*), or the seeds of the Four o'clock flower (*Mirabilis jalapa*).

b. Those plants which have stinging leaves or stems should also be pointed out and avoided in the future, as well as those which have milky juice or latex within the stem or leaves (e.g. species of *Euphorbia*). What plant contains a latex which is not harmful?

(6) to (8): *Small animal life in a garden*

Children will soon become aware of the many insects that live on garden plants, and often will be fascinated by them. They should be encouraged to handle them freely without fear, unless, of course, the insect concerned has the ability to bite or sting. Wherever there are

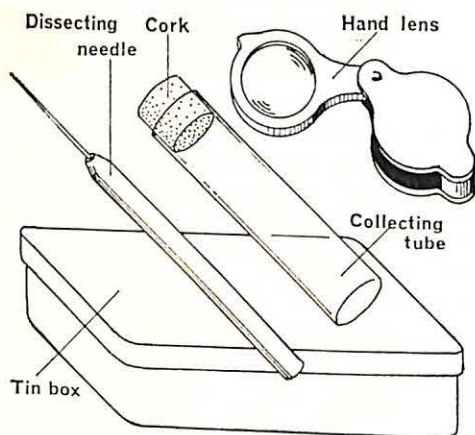


FIGURE 24. Some useful equipment for insect studies

insects there is the danger of being stung, and teachers should learn how to treat stings, particularly those from bees or wasps. Certain kinds of caterpillars, particularly the 'furry' kinds, are to be avoided because they can sting painfully; but beetles are generally harmless, and as they possess hard outer cases to their bodies, are generally suitable objects to collect. After collecting, kill them by dropping

them in boiling water; then mount them with a drop of glue on small pieces of white card, label as required, and keep for future reference.

Many pupils will be attracted by the vivid colours and rapid flight of butterflies, especially when they are seen in large numbers, flying together. Young children will not be able to appreciate very clearly the idea of metamorphosis and, of course, such scientific words will not need to be used by the teacher; but the fact that the form of an insect changes during its lifetime may be understood if an adult butterfly is observed laying eggs on a cabbage leaf, where there are already caterpillars.

Many different kinds of moths will be seen in a garden, although most of these insects move about at night. The long-tongued Hawk moths are of especial interest, if they can be seen taking nectar from those flowers which have their petals joined together to form a long tube.

Amongst the many kinds of bees and wasps, the wood-boring Carpenter bee is an example suitable for children to watch at work. It may be seen visiting its home under the edge of the roof of a building, the entrance to which is a cleanly cut hole about half an inch wide. Later, the bee will be heard cutting away inside, as it enlarges its living space, and large quantities of tiny wood chippings are thrown out from time to time.

Other insects which provide material for lessons will include various kinds of grasshoppers; the mantis and stick insects; the ant-lion, which at the larval stage buries itself in sandy soil and awaits its prey; and if the school is situated near to a stream or pool, the swift-flying, long-bodied dragonfly will often be seen.

Always to be found in gardens are spiders. Their webs, made of the fine thread-like substance which they spin out of their bodies, may often be seen, glistening with dew in the early morning on patches of grass, or on branches of shrubs or trees. Sometimes small spiders may be observed being carried through the air on the wind, whilst attached to a length of gossamer. Spiders, though often disliked, are useful members of a garden community generally, because they feed on insects which may be harmful to plants.

Besides insects and spiders, a garden is the home of numerous other small creatures, and these include scorpions, frogs and toads, slugs and snails, centipedes and millipedes, and various kinds of worms. They will all provide material for lessons, if their habits and appearance are watched patiently by a teacher.

Practical work

a. Try to observe the manner in which various garden insects obtain their food. This may lead to a simple classification of insects according to their feeding processes, such as (i) those which bite, (ii) those which bore into leaves, (iii) those which suck plant juices, (iv) those which seek nectar, and (v) those which feed on other animals.

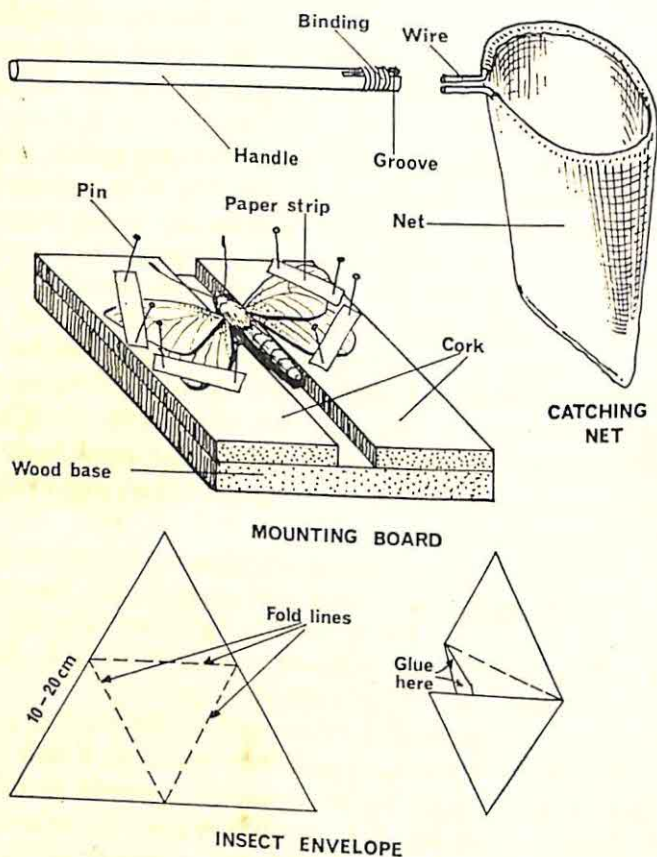


FIGURE 25. Butterfly collecting aids

b. Many winged insects will be seen, but also others which cannot fly. Find examples which have (i) two pairs of wings, (ii) one pair of wings, (iii) no wings at all. Pupils may make drawings, and record on the nature calendar the date and the time of day when they were seen.

c. Make a butterfly net out of fine cotton cloth, fixed to a wire hoop (30 cm diameter), on the end of a long wooden stick; the wire is made secure by binding firmly with thread. Care must be taken to

handle the insects gently, as the coloured powder on their wings is easily brushed off. Small paper envelopes may be made in which the butterflies are put until they reach the classroom for closer observation than is possible in the field. Butterflies may be killed by applying pressure to the body part immediately behind the head (the thorax) with a finger and thumb firmly, yet without damaging the insect.

d. The brightly coloured 'ladybird' beetles form an interesting group of insects for pupils at this stage. Try to observe their association with aphids. What is the larval stage of this kind of beetle like?

e. Look for the homes of insects. Examples are the papery combs of certain wasps: compare these with pieces of honey-comb from a bee hive. Other examples are the cocoons of insects, nests of ants high up in trees, and the earth-mounds of termites.

f. Note the relationship between certain kinds of black ants and aphids. What is the effect of the feeding of the aphids on the host plant? Do the ants obtain anything from the aphids? Supplying children with modelling clay, encourage the making of large-scale models of these insects (see page 44).

g. Make a small 'house' for a toad out of four pieces of glass, fixed together at the edges, and standing in a dish containing gravel. Put soil, stones and some plant material on the bottom and keep it all

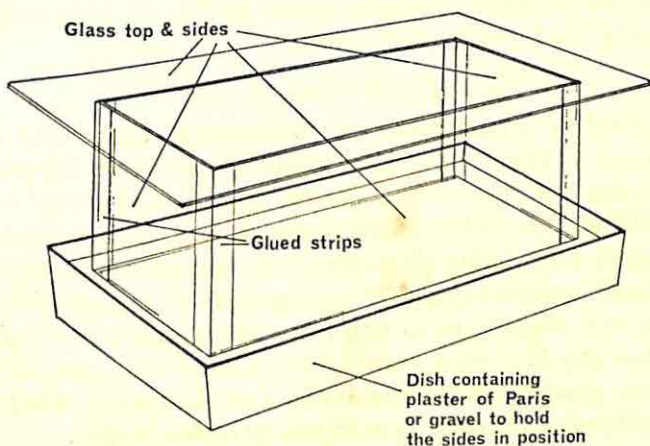


FIGURE 26. A house for small animals

moist. Unless food can be provided, the toad should only be kept under observation for a few hours, after which it should be released. Are toads beneficial in a garden?

h. Search for specimens of slugs or snails in the garden. Note that the former of these two closely related animals has only a 'mantle' to cover the upper part of its body, whereas the latter has a conspicuous shell. Draw attention to the 'horns' on the ends of which are the eyes. Observe how these are sensitive and may be withdrawn into the body. Discover how these animals move, by allowing them to travel over a piece of glass whilst being viewed from below. Are they harmful creatures in a garden?

D. FARMS AND FARMING

Main ideas to be brought out

- (1) A farm is a place where animals are kept and where crops are grown.
- (2) A farm consists of fields and buildings; there may also be implements to help the farmer do his work.
- (3) There are many different kinds of farms throughout the world.
- (4) Farming systems depend on local conditions of geography and human needs.
- (5) Farms may be grouped as animal farms, farms growing crops only, and mixed farms.
- (6) A farmer's work is to care for the farm itself, and to look after the crops and livestock.
- (7) As the plants and animals depend on the soil, the care of the soil is the farmer's chief concern.

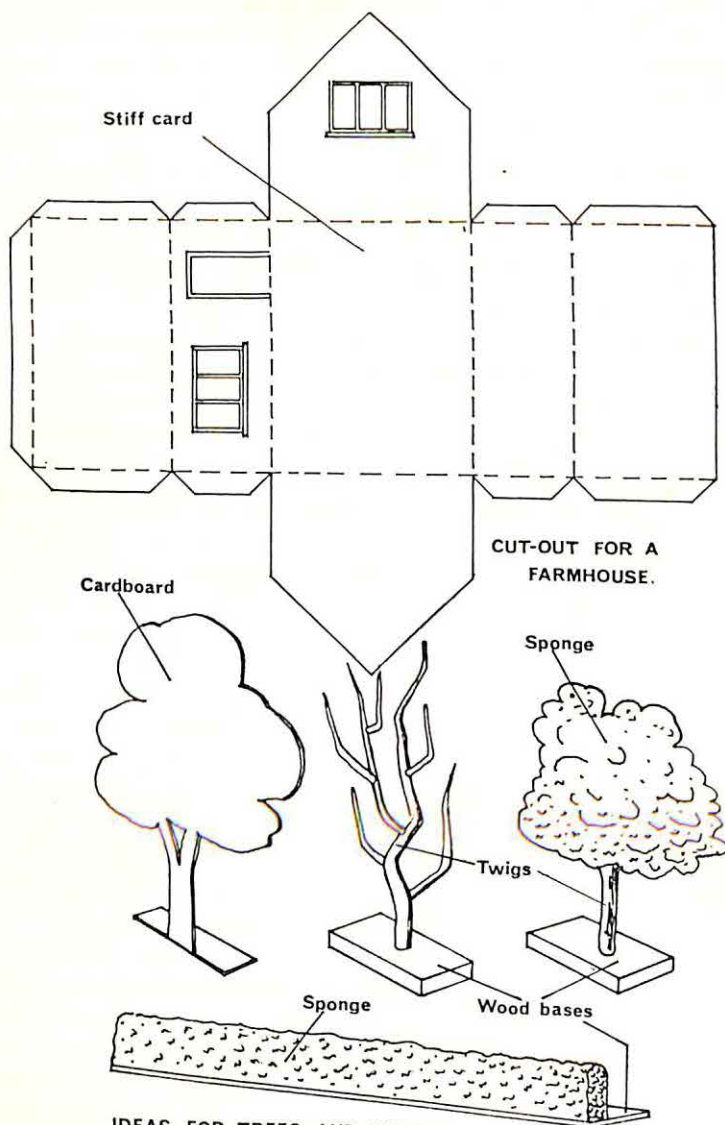
(1) and (2): What a farm is

Most schools in tropical lands are situated within close reach of the countryside, and thus there will be plenty of opportunity for pupils to wonder, and ask questions, about the animals and crops they see around them. This interest should be encouraged as much as possible, by teachers acquainting themselves with whatever goes on in the agricultural neighbourhood. The contacts he makes with local farmers will often prove to be of use educationally in the future. A teacher should also be aware of the variety of farming activities which are practised in the country as a whole, because the locality near to the school is unlikely to be wholly representative.

Many pupils will, of course, live on farms themselves; and this fact may be the basis of a teacher's approach to the study of a farm, stressing the idea that a farm not only includes the fields and the domesticated livestock, but also the buildings and the tools a farmer needs to do his job.

Practical work

a. Build a model farm either indoors on a sand table, or outdoors on the ground. Use clay for making the animals and implements, and pieces of wood, matchboxes or cardboard for the buildings, and pieces of wood, matchboxes or cardboard for the buildings,



IDEAS FOR TREES AND HEDGES

FIGURE 27. Ideas for making a model farm

with small twigs to form the boundaries to the fields, and leafy twigs to represent trees. By altering the layout of the fields, etc., different kinds of farms can be represented. If toy farm animals, implements, etc., are available, they will make the model more realistic; but it should be remembered that they will provide no occasion to investigate the form of objects through the modelling work in clay or other materials. It will be found that the most promising results will be obtained if the children are arranged in small groups for this kind of 'play' activity.

b. A farmer needs more complicated tools than those used in a garden. The most fascinating of these, to children, are the tractor and plough; and if such implements are in use locally, they will be a constant source of interest even to the youngest pupil. It will be whilst out on a farm walk that such farm tools will be seen in use. However, if possible, a teacher should make a collection of pictures from farming magazines, trade advertisements, etc., which pupils can then stick in to their scrapbooks, or from which they can make their own drawings. At this stage, no clear idea of the working of an internal combustion engine can be given; but something of the principle behind it may be suggested by comparing it to the body of an animal which requires food and air in order to live. An engine requires fuel and air, and these substances are used to provide energy (comparable to the way in which animals consume food and breathe in oxygen to give them energy); and the waste gases from an engine pass out of the exhaust pipe (comparable to the way animals breathe out carbon dioxide through their lungs).

(3) to (5): *Different kinds of farms*

Everyone who lives in a rural community ought to have an understanding of the various systems by which the land is used for agriculture. Lesson material for this topic, however, should not be restricted to local examples; and a collection of pictures, diagrams, and written descriptions taken from farming magazines, books, advertisements, papers or posters, will help teachers show children how the land is used elsewhere.

The main systems in use throughout the world are always related to the local conditions of climate, landscape and human needs, and include nomadic pastoral methods and extensive grassland 'ranches'; animal farms, concentrating on one or two kinds of livestock, such as sheep, pigs, or dairy cows; large estates and plantations, growing crops like coconuts, tea, coffee, cocoa, sugar and rubber; mixed

farms, where crops and livestock are cared for on a comparatively small farm; and market gardens, growing vegetables, often for supply to a town. With children of this age, there cannot be a detailed study of any particular system. It will be through the children's questions whilst out on farm walks, or when looking at pictures, that ideas can be brought out. Such apparently simple problems as 'Why does a cow give milk?', 'What kinds of food do farm animals eat?', 'What is the difference between a ranch and a plantation?', are the sort of questions which a teacher must be prepared to answer as clearly as he can.

Practical work

a. What are the local geographical factors which determine the kind of farming which is possible in the school locality? Approach this question practically by making recorded observations of the weather

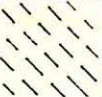
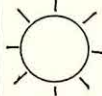
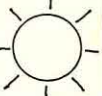
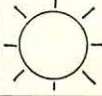
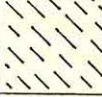
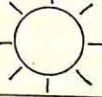
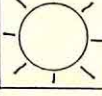
OUR WEATHER CHART		
	Morn	Noon
MONDAY		
TUESDAY		
WEDNESDAY		
THURSDAY		
FRIDAY		
WEEK	NOV 5 - 9	

FIGURE 28. A weather chart

(by keeping a weather calendar up-to-date); and by studying the natural features of the landscape (making simple maps of selected areas).

b. Construct a number of large blank-page 'scrap-books'—one for each kind of farming system described previously, and keep them on the table in the nature corner. Whenever a farming picture is acquired, stick it in the appropriate book, on the right-hand side.

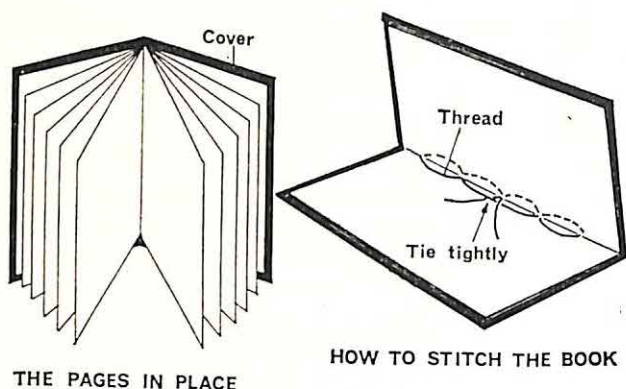


FIGURE 29. Making a scrap book

Selected pupils may then write suitably simple sentences related to the pictures, to be pasted on the left-hand side, opposite the picture concerned.

(6) and (7): *A farmer's work*

This section can best be approached from the point of view of the pupils' own experiences. As the school is likely to be in a rural area, many children will have taken part themselves, from an early age, in the work which needs to be done on a farm. Thus most pupils will know that an important farming activity is the care of the animals: which includes taking them to water, seeing that they have sufficient food, and putting them in a safe, sheltered place at night. Similarly, many pupils will have helped their parents cultivate crops, so that plants may grow without competition from weeds, and so on. They will also know that farm produce must be harvested and taken to market, at the right time, if it is to be made profitable.

The plants and animals will not be able to thrive if the soil underlying the farm is in poor condition. Because of this, a farmer's chief responsibility is the maintenance of the soil in as fertile a state

as possible. This can be achieved in many ways, but the essential problem is how to keep moisture present in the upper layers of the soil, so that the materials from the soil can be absorbed in solution by the plant through its roots. To solve this successfully, throughout all seasons of the year, will involve a farmer in many tasks which will together occupy much of his time.

Practical work

a. Observe the variety of tasks actually done by a farmer during the course of his work. Classify them according to whether they are concerned with (i) plants, (ii) livestock, or (iii) the soil, or (iv) maintenance of the farm itself, including buildings, fences, etc. Whilst stressing that an efficient farmer can be recognized by the quality of his work, insist on good standards whenever the children themselves are working in the garden. No age is too young to teach the importance of always doing a job as well as possible.

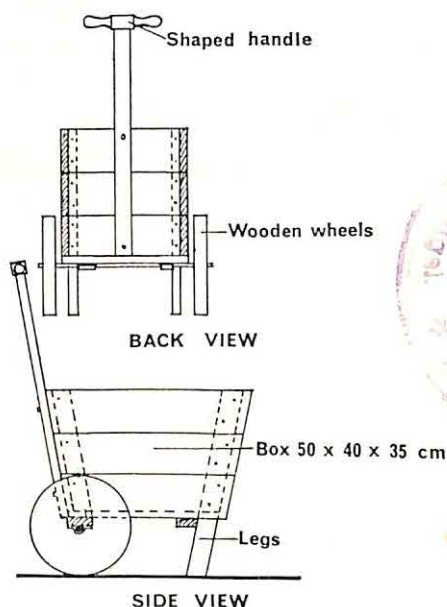


FIGURE 30. How to construct a hand-cart

b. Enlist the help of the local carpenter or trade school, if necessary, in making a two-wheeled hand-cart which can be used in the garden by the smaller children. Get them to take an active interest in its construction. How do farmers convey their produce to market?

c. Demonstrate how to keep tools clean and in good repair. Make this a routine task after every outdoor lesson in the garden when tools are used. Insist also that tools are always replaced in the store after use.

d. The idea of machines as a means of making work easier can be treated in a very practical manner. A selection of objects which will give material for play, yet which will be suitable to use as simple machines, should be acquired. Old wheels, wedge-shaped pieces of wood, a see-saw, made from a plank of wood and a log, are the sort of objects which will be suitable. The mechanical principles behind levers, wedges and wheels cannot be taught at this stage, of course; nevertheless, if pupils are permitted to experiment, through their own play and imaginative activities, aided by a teacher's suggestions and material assistance, they will be introduced to the purpose of such simple machines as these objects are.

e. Start a small compost pit from which pupils will take off material to top-dress the soil around their plants. The advantage of adding animal dung from farmyards and fields may be taught, and the idea

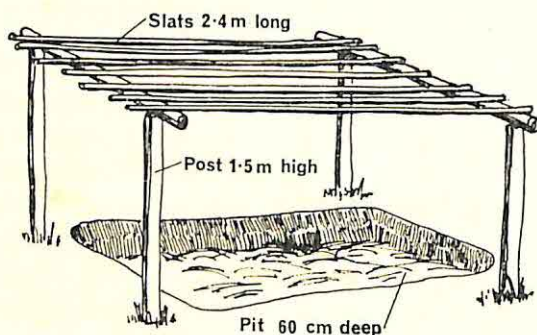


FIGURE 31. A compost pit

introduced that such substances are valuable, and should never be wasted. The composting process will demonstrate that vegetable waste may be used in the restoration of the soil. What methods do local farmers use to care for the soil and keep it fertile?

E. FARM CROPS

Main ideas to be brought out

- (1) Grasses are plants with narrow leaves and small flowers, often supported on tall stems.

- (2) Grasses spread everywhere very easily; they have densely matted fibrous roots.
- (3) Grass is the most important food for farm animals.
- (4) Grass may be grazed by livestock, or cut and stored for future use.
- (5) There are various other fodder crops grown on farms besides grass.
- (6) Many other plants are grown on farms to be used by man.

(1) and (2): What a grass plant is

Grass plants may be found growing nearly everywhere, and some idea of how they differ from the more obvious kinds of flowering plants may be learnt. All grasses are good examples of plants which are pollinated by wind, and they have the characteristics of such plants: colourless or absent petals, tall waving stems generally, and hanging stamens. Grasses also have a particular type of grain which has developed out of a one-seeded ovary. The vegetative parts of grasses are noticeable by the presence of short hair-like roots, although grasses also often possess long, deeply penetrating roots, or underground stems, which enable them to spread easily. Their leaves are typically long and narrow, and generally spring from the base of the plant, beginning in the form of a sheath around the stem. Some of these characteristics account for the presence of grasses in most regions of the world and their persistence under all conditions.

The seeds of grasses are often small and sometimes they are not visible without a lens, but some of the cereals (millet or maize, for example) which are grasses, have larger seeds. These cultivated grasses are useful examples to show that not all flowers produce pollen on the same part of the flower as the seed.

Practical work

- a. Help children to collect grasses, digging up clumps of each kind with their roots. Observe the leaf, sheath and blade; the round stems (generally hollow with swollen nodes at intervals up the stem); fibrous roots; underground stems forming new roots at the nodes; and the flowerhead, both before opening and when fully out.
- b. Permit children to chew a few grains of a cereal, such as maize, in order to familiarize them with the taste of raw starch. Cut open a grain and examine it. Discuss its contents.
- c. Germinate some maize seeds in moist sawdust. When a few inches

high, wash the roots and look for root-hairs and the first leaf-shoots. Compare with some bean seedlings grown in a similar manner.

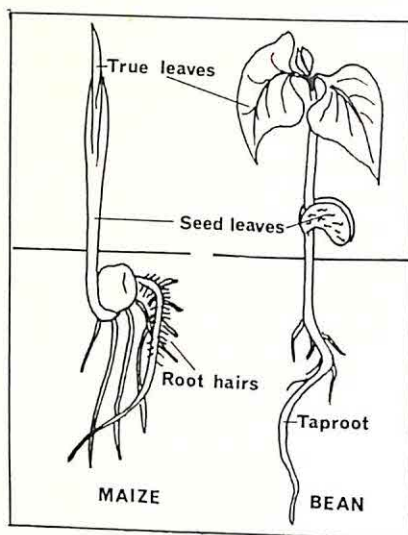


FIGURE 32. A blackboard sketch of seedlings

- d. Try to find out which other plants in the garden have leaves similar to those of grasses in respect of the leaf-veins. Do any trees have leaves of this kind?
- e. Examine the 'florets' on a flower-head of a large grass, such as bullrush-millet. Ask the pupils such questions as, 'Have all the florets got stamens?', or 'Are any petals to be seen?'
- f. Press some of the best grass plants collected between sheets of newspaper under weights, as before, and mount on pieces of white paper and label as usual.

(3) and (4): Grass as food for animals

The idea that grass is a crop to be cultivated just like any other is slow to be appreciated, even by adults; therefore, the fact that farmers often sow a whole field with the seeds of grasses, or plant the roots, may be learnt by observing this aspect of a farmer's work, whenever suitable occasions are at hand.

The ground within the school area around the cultivated plots and buildings, where children spend much of their play-time, may be similarly planted with a suitable kind of grass, which should be kept cut close to the ground: grasses planted for such a purpose should

never be allowed to produce flowers. Repeated cutting will encourage the spreading habit of growth of the plants and a uniform 'lawn' will be the result.

On a farm, grass is usually grazed by cattle or sheep, and observation of these ruminants feeding will lead to an understanding of how they use grass. They will be seen first to eat the grass whilst moving over the field; but later they will lie down and, returning the food which they have swallowed to the mouth, chew it again.

Even if it is not used in the locality, in lessons about farming methods in more temperate lands, children will hear about hay-making. The fact that it is not just grass allowed to dry in the sun and air whilst still rooted in the ground, but is in fact, grass cut when it is at its most leafy stage, and then dried rapidly, is the essential idea to stress.

Practical work

- a. Visit the fields of a neighbouring farm and collect as many kinds of grasses as possible. Gather them when the flowerhead is fully formed, and keep in jars of water in the classroom.
- b. On the farm, notice which kinds of animals are grazing the grass-land. Try to discover at which time of the day they are actually eating the grass and when they are generally 'chewing the cud'. Do all animals which eat grass have this habit? Do farm animals keep regular habits as regards the times when they are grazing?
- c. If it is possible to see good quality hay, compare its feel, smell and appearance in general with that of ordinary dried-up grass. What other kinds of plants besides grasses can be found in the hay?

(5) and (6): Other farm plants

Many plants, besides grass, are grown to feed livestock, and some of these may be seen on farms near to the school. They may be leafy crops, plants grown for their seeds or grain, or root crops. The kind of questions to ask pupils in this connexion are, 'What part of the plant is the farmer going to feed to his animals?', 'Why does the farmer need to grow special food for his livestock?', 'At what season of the year will he give the food to them?', and 'What method does the farmer use to feed the plants—does he cut them first or let them be consumed in the fields?'

Most children will know that some plants are grown on farms specially to be sold and not used as food either for the farmer himself or for his animals. These crops are often the main source of

people's income in tropical lands. Though some are food plants, many of them are grown to be used eventually for purposes other than as food.

The most suitable approach at this stage is to learn about these plants by studying particular specimens which may be found growing locally. The aim, however, cannot be to acquire much detailed knowledge about any of them, but to make known something of the variety of plant parts which can be used by human beings for all sorts of purposes. Though a formal classification should not be attempted, the children should be familiar with the most important of these products. They should know, for instance, that many of the necessities of life such as furniture, clothes, mats, bags, paper,

refreshing drinks, medicines and drugs, oils, dyes, gums, and rubber, all come from substances obtained from plants, most of which grow in tropical lands.

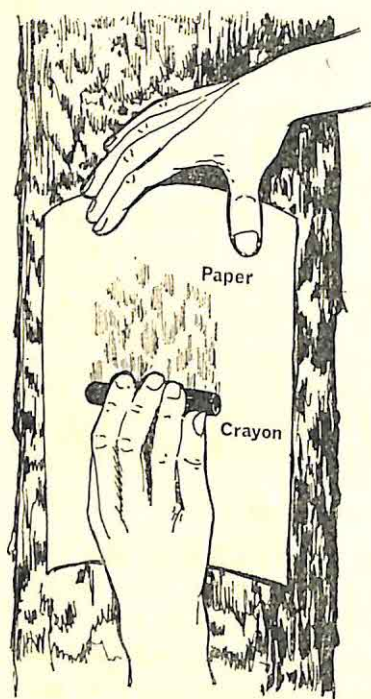


FIGURE 33. Taking a bark rubbing

Practical work

- a. Make a visit to the place where fodder crops are known to be cultivated. Bring back examples of (i) a leafy plant, (ii) a root crop, and (iii) a plant grown for its seeds. Make drawings of them.
- b. Take the seeds off the seed plant and squash them under a piece of wood on a clean sheet of paper. Do they contain any oil? Taste them and describe the flavour.
- c. Examine the root crop by cutting open the root itself. Does it contain much moisture? Taste some of the fleshy part of the root. Does it contain sugar?
- d. Examine the leafy fodder crop. Is there any food stored in the leaves? If so, where in the leaves is it contained? Are the leaves dry or do they contain much water?
- e. Collect pieces of the bark and sawn-off sections of branches of local trees which are used for making chairs, tables, etc. Compare the

wood for smoothness, weight, colour, and scent. Is the wood fine-grained or not? Does it contain many 'knots'? Is it hard when cut or soft? Explain the function of the bark and its importance to a tree. Make a collection of bark rubbings using the method shown in Figure 33.

f. Make use of local fibres obtained from plants for hand-work. For example, children may make small mats, bags or small animals, out

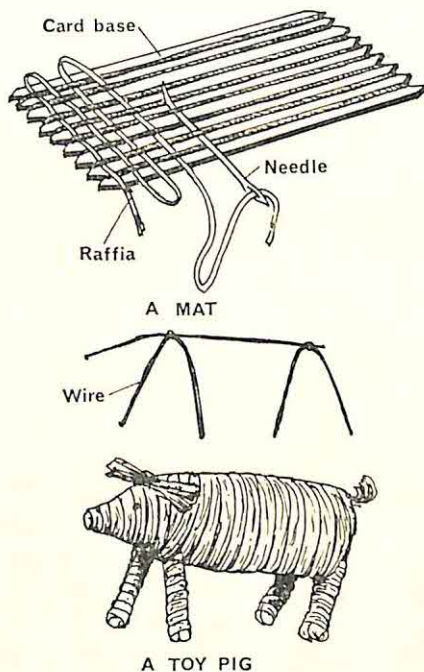


FIGURE 34. Examples of objects made from fibres

of raffia or sisal. How are the fibres extracted from the plant? Talk about cotton and its great value as a fibre crop.

g. Encourage children to bring examples of other kinds of plant produce which can be used in any way. Build up a display on the nature table, and make use of whatever opportunities arise for lesson work. Examples might be pawpaw leaves used for making meat tender, or wattle bark for tanning.

F. FARM ANIMALS

Main ideas to be brought out

- (1) Small animals kept for pleasure and interest are called pets.

- (2) Pets need food and water, protection from weather, and from diseases and pests.
- (3) There are many different kinds of farm animals.
- (4) Farm animals may be recognized by the bodily characteristics.
- (5) There are many kinds of wild birds, mammals and other creatures to be seen in a garden; they are all named and can be recognized.
- (6) Most birds and mammals are harmless, but some are enemies of garden and farm plants.

(1) and (2): Animals as pets

Practical work

This activity is one which will continue throughout each term. Whichever kind of small animal is kept as a pet, the work will mostly take the form of daily tasks; and the best way to organize these is to divide the pupils into pairs, each of which will be responsible in turn for the feeding, cleaning or watering of the pets, under the general guidance of the teacher. It will be found convenient to arrange for these duties to be completed first thing in the morning when the children come to school, and last thing after lessons in the afternoons.

In Chapter 2 certain principles regarding the care of small animals, such as rabbits and pigeons, were outlined. Reference was made particularly to the kind of housing they require, and which must be completed before the pets are acquired. It cannot be repeated often enough that wherever small livestock are kept, they must be looked after properly in suitable accommodation, wherein they will be given adequate protection in every way. A notebook, in which the most interesting facts of the animal's life are simply recorded, may be started, different pupils taking turns to make the entries in writing or in picture form, as desired.

(3) to (5): Recognizing farm animals

The aim should be simply to enable the children to become familiar with the common kinds of domesticated livestock and their uses, leaving the distinction between breeds until later. Lesson work related to this aim should be firmly based on observation, however, stressing the characteristics which distinguish each kind.

An important consequence of the aspect of the topic related to the use man makes of his domesticated animals, will be the teaching of

the correct attitude of mind towards them. The need for kindness in general, and the considerate handling of animals, may be brought out when observing donkeys—beasts of burden which are often maltreated. The idea that animals will give a better return if they are fed properly and watered regularly, given suitable shelter and kept in good condition, must be stressed, as well as the desirability for careful management on purely humanitarian grounds.

Practical work

Build up a collection of pictures of domesticated animals of all kinds and from all over the world, and paste them on to cards. Write the name of the animal alongside and use these cards to give pupils lesson work in which they will (i) make drawings of the animals, (ii) compose simple sentences to bring out the most obvious characteristics of each, and (iii) learn about their value to man and why he has domesticated them.

An activity like this, or the 'scrap-book' suggested for farming systems (page 76) or for dried leaves (page 61) can well be kept for occasions when outside activities for some reason or other are not possible.

(6) and (7): Wild birds and mammals in a garden

The overall aim is to discover which creatures are harmful and which are beneficial. Careful observation is again the method to adopt.

A school garden affords good opportunity to attract wild birds if they are provided with food (for which a special feeding table may be built), and water for drinking and bathing. If such a table is sited in a position where it can be enjoyed by the children without disturbing the birds, much will be seen of their habits and behaviour. Similarly, nest boxes may be put up on trees in the shade, or under the eaves of buildings. (Figure 35.)

Not many mammals will normally be seen visiting a school garden. Those which do are usually small rodents or nocturnal creatures, such as moles, porcupines, etc. They are mostly harmful. Occasionally small buck, or even wild pigs, will try to enter a garden, seeking food. This is the occasion on which to point out that the only really effective way of controlling such animals is to protect the garden by means of a stock-proof fence or hedge. If they do break in, it will be possible to see the damage done by examining the leaves and shoots of herbaceous plants and shrubs, and noting where roots have been dug up.

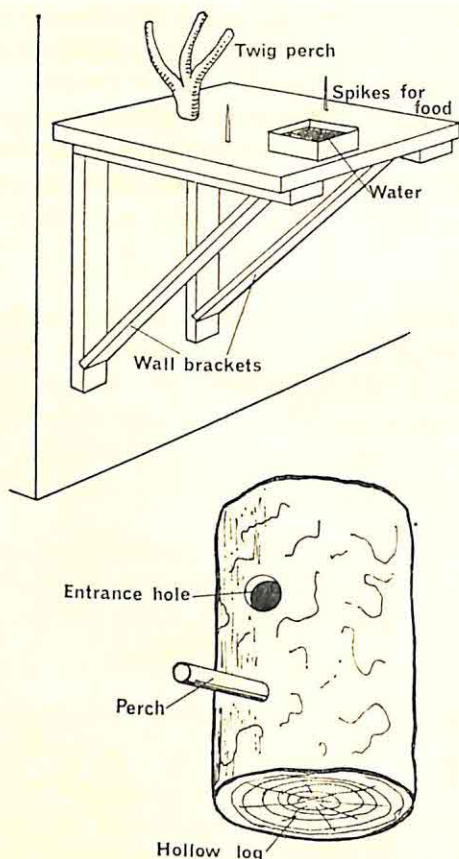


FIGURE 35. Designs for a bird table and a nest box

Practical work

a. Various parts of the bodies of mammals and birds will be found occasionally in a garden, and these can be collected. Examples are feathers, bones, skulls, beaks and feet of birds, bits of fur or hair from mammals; even the droppings of animals may be examined, as they sometimes prove of interest by indicating the kind of food the animal eats. Pellets disgorged from the mouths of birds of prey, such as owls, are also of great interest in this respect.

b. Try to find the tracks left by animals. If possible, discover where the animals have come from, or where they have gone.

c. Children may be helped to discover which animals have attacked which plants. Gnawing animals, like rats, damage roots, fruits, and seeds; small cats will sometimes take fruits; porcupines eat roots;

pigs may uproot whole plants, as well as consuming grain; the leaves of small trees and shrubs are eaten by antelopes. Keep records of such evidence whenever observed.

d. Compare the different kinds of birds visiting the garden by noting their general size, their feather colour, the shape of their beaks, and the pattern of their flight. A helpful idea is to use a very common

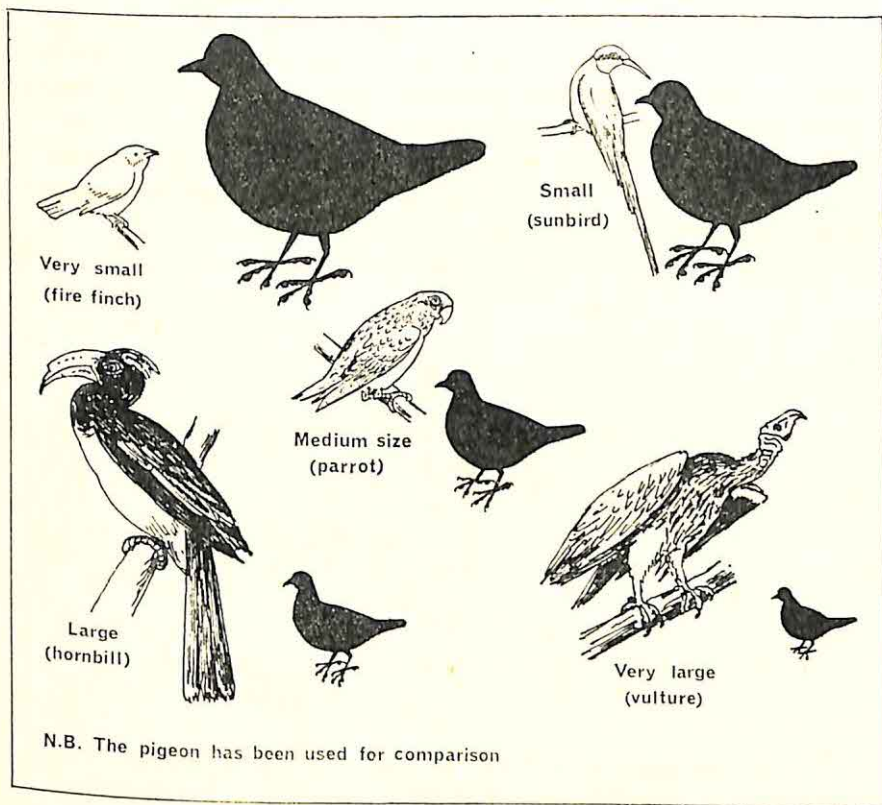


FIGURE 36. A method of comparing birds by their size

bird of medium size, such as one of the well-known seed-eating kinds, as a basis of comparison. Others may then be described as being either very small, small, medium size, large, or very large, in relation to the chosen type.

e. The sounds made by mammals and birds often prove to be of the greatest interest to small children. The cry they make can be used as a means of recognition. For example, some hornbills have a cry which might be described as 'Aack-aack'. Other kinds of birds which have a

distinctive and recognizable cry are the plovers, ravens, ibises, owls, bulbuls, turacos, parrots, pigeons, and many birds of prey. As a result of discussions, try to arrive at descriptive words representative of such sounds as they make.

f. The young of all creatures are fascinating to children, and they should be watched whenever possible, and notice taken of how the parents care for them. Birds' eggs will often be found; and it may be taught that if it is wished to have birds in the garden, their eggs should be left undisturbed in the nests. If eggs are collected, teachers ought to learn how to 'blow' them properly, so as to preserve their shells for the future, empty of contents. The main points of interest about birds' eggs are their differences in size and shape, their beautiful colouring, and the fact that they tend to merge with their surroundings when in the nest.

CHAPTER 5

Material for the Third and Fourth Year Lessons

A. THE SOIL

Main ideas to be brought out

- (1) Decayed plant and animal matter in the soil is called humus.
- (2) Humus is rich in minerals used by plants to make food substances; it also holds the moisture in which the minerals are dissolved.
- (3) Compost is artificially prepared humus; plant and animal matter is rotted down with the aid of moisture and the living organisms which develop in it.
- (4) Plants take in, through their roots, the food substances dissolved in soil water.
- (5) Moisture will be held in the soil if humus is present.
- (6) Soil will remain moist if it is shaded from the sun, kept free of weeds, and is well mulched.
- (7) Special tools are used for soil cultivation; they depend mainly on the lever principle.
- (8) Garden tools are used for digging, cutting, soil cultivation, and for transportation.
- (9) Care must be taken to avoid accidents whilst using tools.
- (10) Immediately after use, tools should be carefully cleaned and then stored away.

(1) to (3): Decay and soil fertility

The reluctance of farmers all over the world either to make compost or to use farmyard manure, indicates that the relationship between decay and soil fertility is not properly appreciated, even by adults. The need to teach the principles of soil fertility throughout school years is apparent, though this is not an easy topic for young children to understand. The visible consequences of neglect should be constantly indicated.

Observation must be closely related to the practical work in the garden, and continued throughout the whole time pupils are in school. Any observations and results of experiments should be

recorded in field-work notebooks, and conclusions drawn whenever possible.

At the outset, it may be necessary to teach that plant food in humus is in the form of mineral salts which are invisible, being dissolved in the soil water before they are absorbed by plants through their roots. It may be possible to manage this introductory work without actually using the names of specific mineral salts, such as nitrates, phosphates, or carbonates; but the methods by which plants take in these substances and send them to every part can be demonstrated, and some simple suggestions as to how this might be done are included in the section on practical work.

It will be observed that all parts of the garden are not equally fertile, and in discussing how to make them so, the use of compost would be one possibility mentioned. During the practical garden work this kind of manure will, of course, be made. The results of

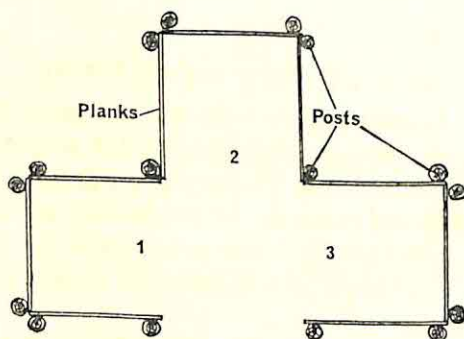
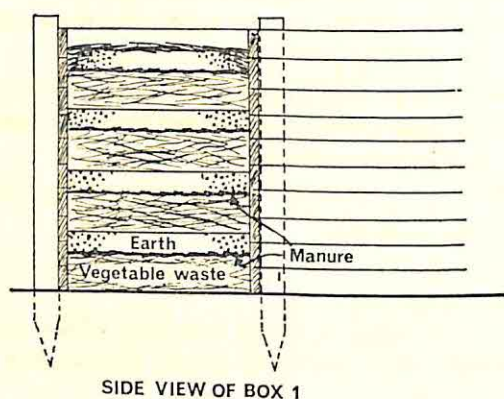
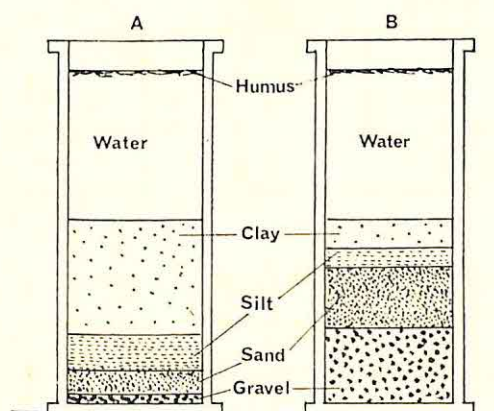


FIGURE 37. Making compost in a box

making it in a pit, a box, or in a heap should all be compared, as could compost made from different materials. The idea that the rotting-down process depends on the presence of invisible living organisms, such as bacteria and fungi, is the key to the understanding of how a compost heap works. As all living things need moisture and air, the need to turn decaying material from time to time, to ensure that these substances are available for the organisms in the compost, will be appreciated, as also the need to add water if the material becomes excessively dry.

Practical work

a. The meaning of a solution may be revised by dissolving some common salt in water. It should be explained that the salt has disappeared because the particles of the chemicals of which it is composed have *mixed* with the particles of the water. They have not *combined* chemically, and this may be proved by allowing a small amount of the water in the solution to evaporate slowly in an open dish, so permitting the formation of crystals of common salt. This experiment may be repeated with other salts, such as copper sulphate



Sample	Clay	Silt	Sand	Gravel
A	64	19	11	6
B	17	11	33	39

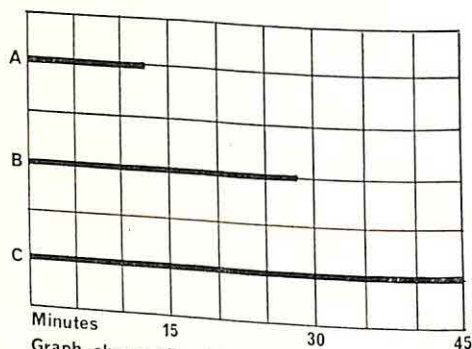
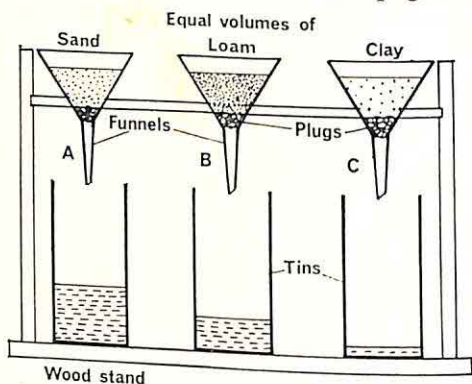
FIGURE 38. Comparing the composition of different soils

(blue-stone), or magnesium sulphate (Epsom salts), if they are available.

b. In the garden, build a compost pit and a compost box. Prepare samples of compost in each, using layers of waste vegetable matter; animal dung (if obtainable—if not, some old mature compost should be included); and a quantity of garden soil, in that order from the bottom. Repeat the layers until the whole mass of material is the required height. Keep compost moist and shaded. Which system would be preferred in a situation exposed to drying winds?

c. Observe the evidence for the presence of living things active in composting material by feeling the heat they generate, when the arm is thrust into the heap. Look for 'toadstools' on the surface of the heap soon after it has been made. Aim to become familiar with the characteristics of good quality compost. What does it smell like? What is its colour? Is it moist? Is it heavy or light in weight?

d. Fill tins with samples of different soils (see page 98 for four suit-



Graph shows time taken for equal quantities of water to pass through each soil sample

FIGURE 39. Comparing the water-holding capacity of soils

able localities) and sow the seeds of beans (or other quick-growing plants) in them. Keep note of the time of sowing and the subsequent times of watering. Try to keep the condition of the soil samples the same, all the time, so that the results may be compared.

e. Shake up some of the soil samples in water in glass jars and allow them to settle. Compare the proportion of the components in each by measuring the depths of the deposits of gravel, sand, silt and clay.

f. Test each sample of soil for its moisture-holding properties, using a simple type of apparatus. (Figure 39.) Record the result on graph paper.

g. Weigh out equal amounts of the various samples and dry them in the sun. Then add equal quantities of water to each and again leave in the sun to dry. Note the time taken for each to become dry again, and record the results comparatively on graph paper. What is the effect of the humus content in each soil sample in helping to retain moisture? (Figure 40.)

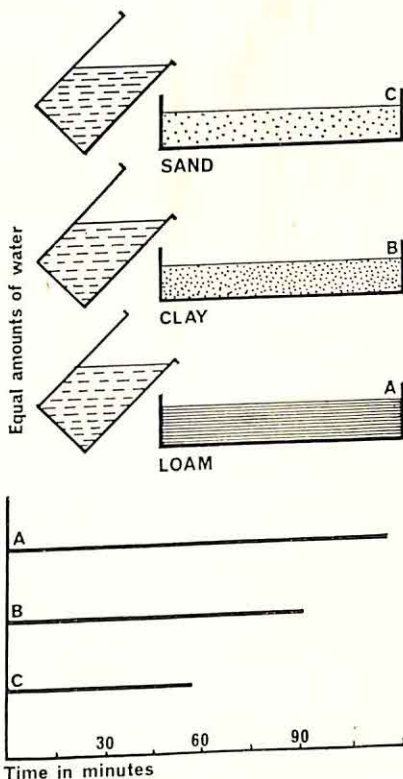


FIGURE 40. A soil experiment



h. Test the soil samples for lime by adding a little weak acid to each. (Vinegar, which is acetic acid, may do.) Bubbling or frothing, called effervescence, will take place if the lime content in the soil is high.

(4) to (6): *Conserving soil moisture*

One conclusion of the work done on soil fertility will be the realization that soils which retain moisture best, always have an adequate humus content. Though water may be applied to the soil artificially by various methods, it is rain water which must be relied on as the

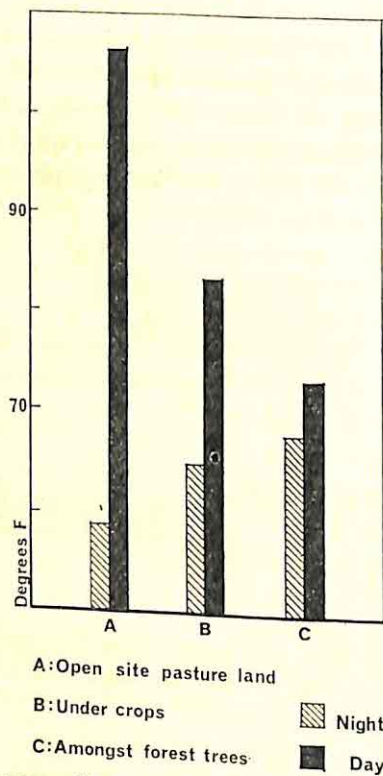


FIGURE 41. Comparing soil temperatures

main source in most places. Water from any source, however, cannot remain for long in the top-soil if there is nothing there to absorb it, and a spongy mass of decaying vegetable matter, like humus, is ideal for the purpose.

Much can be done to help the humus hold the moisture, and this all concerns the provision of shade from too much heat of the sun. The various methods may be taught practically in the garden; and with

the help of simple experiments the principles behind what is done can be stressed.

Practical work

a. Repeat the same experiment for testing the moisture-holding property of soil as outlined above, but in this case, use specifically sub-soils which are mainly sand and clay particles containing no humus, and compare them with good rich loam containing plenty of vegetable mould.

b. Test the value of shade by actually taking soil temperature measurements (i) in the open, (ii) under the shade of isolated plants, and (iii) in dense shade.

c. It is the water obtained from the soil by the plant and contained within the living cells of its stems and leaves, which is the main reason why it supports itself rigidly. Demonstrate turgidity and wilting by placing branches of herbaceous plants in jars containing, (i) fresh water, and (ii) no water. Observe the results after a few hours and discuss what has happened. Why have the leaves of the plant standing in the empty jar collapsed?

d. To show how substances obtained from the soil pass up the stems of plants and enter the leaves, stand a cutting of a plant in water which has been coloured with red ink. The ink will be seen passing along the veins of the leaves; and if the stem is cut across, with the aid of a hand lens, it may be seen in the bundles of tubes which run vertically up the stem.

e. Question pupils as to the reasons for mulching. Explain how a mulch can be made out of the soil itself, and demonstrate its effectiveness. Fill two flat plant pots with equal amounts of soil, having

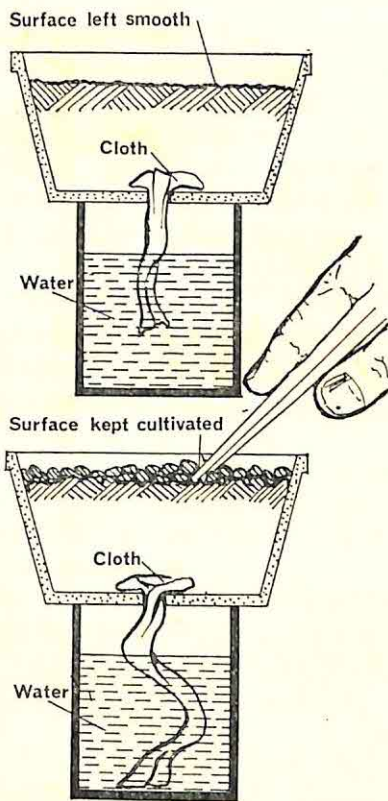


FIGURE 42. An experiment to demonstrate the value of hoeing

pieces of cloth passing through the holes in the bottom into water contained in glass jars on which the pots are standing. Put equal amounts of water in each jar. Keep the apparatus on the nature table for about a week, hoeing the soil surface in one pot daily with a piece of stick, to form a loose 'mulch' of soil. Note the difference in the amount of water left in each jar. (Figure 42.)

f. Make outdoor observations of mulched and unmulched soils, in order to attempt to answer questions such as, 'Which plant materials are most suitable for mulching?', 'Which are not suitable?', and 'What is the effect on the composition of the soil of heavy mulching, often repeated?'

g. Try out some simple experiments on irrigation. Divert a stream on to a small area of land and find out which plants benefit particularly from the increased water supply. Which suffer from too much water? As a result of this, discuss the advantages of having an artificial water supply to a garden. What would be the difficulties involved in the provision of water to a farm? What are the advantages of a piped water supply compared to an open furrow system?

(7) to (10): *Garden tools*

Although there will now be an opportunity to teach something about the mechanical principles behind the use of tools, it is just as important to give instruction in the right way to handle them, so as to get

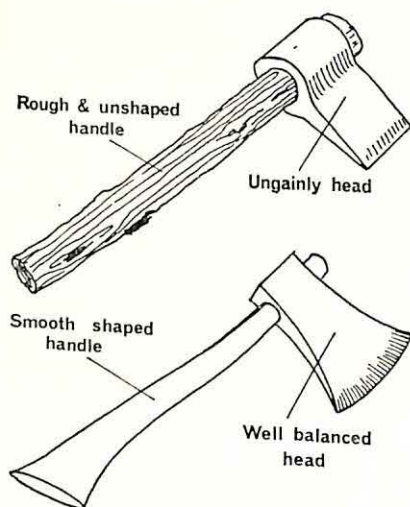


FIGURE 43. Showing how a tool may be badly designed or well designed

the best advantage with the least expenditure of energy. This will include, no doubt, some simple reference to principles such as those of the lever, wedge and wheel. Some garden tools, however, do not involve mechanical effort of this kind; for example, hoes and rakes, used for levelling the surface of the soil either before or after sowing, involve a push or a pull rather than any other kind of action.

Try to convince the children that the look and feel of a tool is a guide to its effectiveness. For example, compare the handle of a tool carefully made to fit the hand, with one that is roughly shaped with no thought for the hand which is to hold it. (Figure 43.)

On all occasions, care must be taken to see that accidents do not happen whilst tools are being used by children. For example, adequate distance between each child must be insisted upon when groups of pupils are working with hoes and digging tools in restricted areas; similarly, special care is needed when cutting tools, such as sickles, axes or matchets are being handled. Teachers of rural science should, nevertheless, have available a supply of simple first-aid equipment to deal with minor injuries, if and when they occur.

Practical work

- a. Compare simply the lever principle operating in such garden tools as digging spades and draw hoes. Relate this to lessons on the same topic in general science. Where is the best place to apply the leverage on the handle in each case? (See specimen lesson on page 45.)
- b. Demonstrate the function of the wedge by means of an axe. Teach the importance of a wedge being of correct shape if it is to be most efficient. In what way is the principle behind the use of a wedge similar to that of a lever?
- c. The wheel, as an aid to doing work, is exemplified in the common garden tool called a wheelbarrow. By means of diagrams, use this

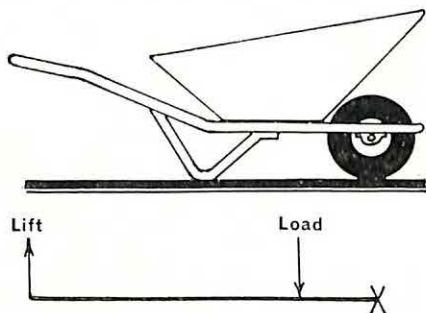


FIGURE 44. The lever principle in a wheelbarrow

implement to show how the lever principle is incorporated in its construction. Where should the load be placed? Where should the handles be grasped?

d. On completion of any work involving the use of tools, they should be put away clean. Demonstrate the best way of cleaning tools, including the oiling of metal parts, wooden handles, etc. How can blade tools be kept sharp?

e. When time allows, as on days unsuitable for gardening due to the weather, make simple racks on which tools may be hung in the store. Explain that the reason for caring for tools properly is that they are expensive to buy or to replace if lost or damaged; and that dirty, rusty tools are difficult to use, and therefore less efficient than tools kept in good condition.

PROJECT WORK

To keep up the fertility in the soil and not lose the moisture it naturally contains, are the essential aims of all cultivation work; aims which in practice have always proved to be extremely difficult to fulfil. Teachers should be aware of this at all times during the teaching of rural science lessons related to the soil. The two main topics of this section, the conservation of soil fertility and soil moisture, may be combined satisfactorily in the form of a project, which will also include practical work involving the use of tools.

To begin with, divide the pupils in the class into groups, and set each the task of undertaking a piece of work related to a chosen plot of ground. The plots should be on ground of different types, which will depend on what is accessible, but the following are possibilities: An area of good garden soil; A plot of woodland soil; A patch of dry sandy soil; A stretch of steep eroded soil.

Visit all the sites with all the pupils to begin with, and discuss the possibilities. Then set each group of pupils 'questions to answer', in respect of their own particular site. For example:

To what depth does humus extend in the soil?

What kind of material is going into the formation of humus?

Is the soil capable of growing healthy plants or not?

Is the soil moist or dry?

Is animal life much in evidence in the soil?

Is there evidence of surface water flowing?

How is the soil on the plot drained?

Is the surface of the soil shaded or not?

The observations which the children will need to make in order to attempt answers to such questions must be recorded in their field-work notebooks, and a sufficient number of periods should be allowed for the whole project to be completed satisfactorily. After the recording stage, for instance, all the groups may be instructed to put their individual records together, along with any collections which may have been made, in the form of a display in the classroom. Finally, a classroom lesson should be held to compare results and draw conclusions.

B. GARDEN PLANTS

Main ideas to be brought out

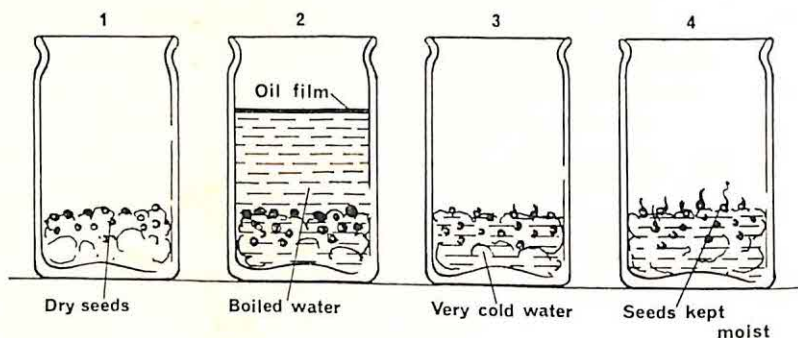
- (1) Air, moisture and the correct soil temperature are the conditions required for seeds to germinate.
- (2) Seeds may be sown in a seed-bed or box; a fine soil texture is required.
- (3) The surface of a seed-bed should be level to prevent loss of surface water; shade from direct sunlight is also necessary.
- (4) Seedlings require moisture, sunlight, root space and a fertile soil in which to grow.
- (5) Seeds must be selected specially for their size and quality.
- (6) Seeds should only be collected from well-grown, healthy plants.
- (7) Seeds must be stored in a dry, well-ventilated container or building.
- (8) Growing plants need sufficient space in well-cultivated fertile soil; thinning and hoeing may be necessary later.
- (9) Plants require sunlight and adequate water and air, but also protection from strong winds.
- (10) Some plants require shade from the sun; others like full sun.

(1) to (4): Seed sowing and transplanting

The conditions required by seeds to germinate are related to the basic needs of plants. These are achieved under natural conditions only at certain seasons of the year; but in a garden, they have to be provided artificially, by protecting the seeds in the soil from too much heat or cold, by watering them, and by taking care to see that the seeds are actually in contact with the soil. Teachers must anticipate their needs for later lessons, and sow seeds some weeks before the start of the natural growing seasons, so that seedlings will be

ready for transplanting when the ground is sufficiently moist; but of course, this advance preparation can only be done if a water supply is available for the seeds in the school garden.

Large seeds, such as those of beans, maize, gourds, etc., may be sown direct into the soil in the garden where they are to grow; but small seeds, such as tomato or cabbage, and most flower seeds, will be



JAR	CONDITION	WHAT HAPPENED
1	No water	No growth
2	No air	Seeds swell only
3	No warmth	Seeds germinate slowly
4	Water air & warmth	Rapid germination

FIGURE 45. Testing the conditions necessary for germination

more successful if first sown in a box or specially prepared seed-bed. There they may be given close attention during the early stages, and later transplanted out to obtain sufficient space in which to continue growing. Some other seeds, like castor, do better if soaked in water before sowing, to ensure even germination: which these are may be discovered experimentally.

Seeds of most plants germinate best in the dark; and furthermore, if there is too much sunlight, the soil will become dry, therefore it is necessary to shade them. It is possible to have a special open-sided hut for this purpose, built in the garden.

The soil in a seed-bed needs to be a rich loam and must be cultivated to an especially fine tilth; the surface should be levelled off before the seeds are put in, and afterwards made firm, with the seeds

properly covered with a thin layer of soil. Shade of a temporary nature will be required in this case.

As the seedlings begin to grow, more light may be permitted, taking care that the soil does not dry out. Later they will need transplanting to another bed where they can have more space. With vegetable seedlings, such as cabbage, it is usual to do this when four true leaves have formed. It is wise to keep the soil around young seedlings mulched to preserve moisture; and it will be essential to shade the seedlings temporarily until they have become established in the new bed.

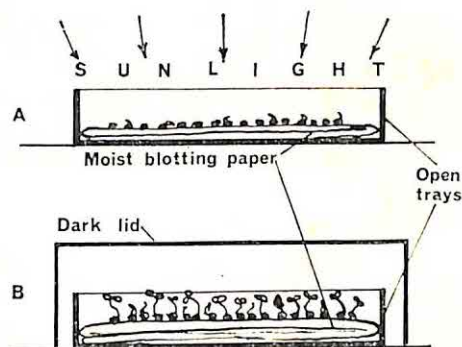


FIGURE 46. To compare the germination of seeds in sunlight and shade

Those seedlings which have been grown from seeds sown originally in their final positions in the garden, will almost certainly need 'thinning-out' to give them adequate growing space. If a few patches are left unthinned, plants may be compared later, to make obvious the advantages of this action.

All the ideas and methods connected with seed sowing and seedlings mentioned here can be brought out during practical work. Teachers should be ready to demonstrate in simple ways the principles concerned, in response to pupils' questions such as, 'Do the roots of seedlings always grow downwards into the soil?', or 'What happens to a seedling which never receives any sunlight?'

Practical work

a. Obtain some heavy clay soil, some light sandy soil, and some good rich loam. Put equal amounts in similar tins and sow seeds in each. Provide the same amount of fresh water each day and compare the results as regards germination and subsequent rate of growth of the seedlings.

b. Using a mixture of sand, compost and garden soil, give a lesson on the use of a seed-box. Relate the facts to the needs of germinating seeds. How may the seeds be kept moist? What is the best way of sowing very tiny seeds?

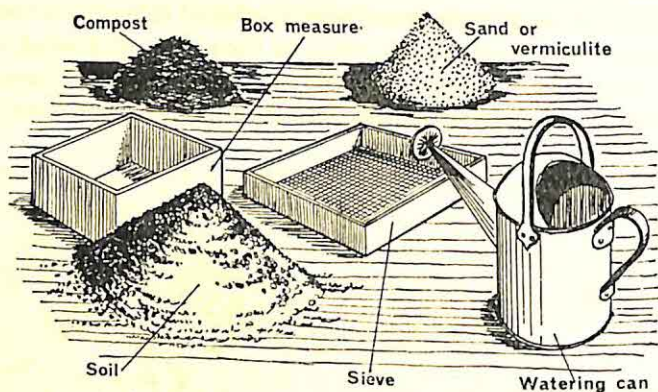


FIGURE 47. Making a soil mixture suitable for seed boxes

c. Demonstrate the transplanting of seedlings. Teach that a dibber or a trowel may be used for this work. What does 'pricking out' mean? What is the best time of day to transplant?

d. Examine the tap-roots of seedlings of carrot or cabbage plants and stress that this part should not be damaged during the transplanting process. Prove this by trying to grow a plant with a broken tap-root,

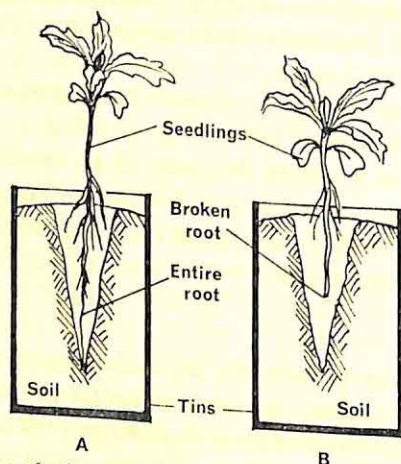


FIGURE 48. To show the importance of transplanting seedlings with their roots entire

as shown. Emphasize also that delicate root-hairs of other seedlings must not be damaged, and that a ball of soil should be left around roots, if possible, whilst moving them. Show pupils how to handle seedlings, holding the stem above the roots lightly between thumb and forefinger.

e. Transplant some seedlings in the early morning, and then a similar number in the late afternoon of the same day. Compare the results after a while to discover how well the former have survived, as they were exposed to the heat of the day immediately after planting out.

f. Encourage children to try to recognize the different plants by the number and shape of the first tiny seed leaves (cotyledons) which appear above the soil surface. Observe which plants have cotyledons which remain below ground.

(5) to (7): *Seed selection and storage*

Seeds need to be specially selected in order to obtain choice samples from which a new crop may be grown, or to obtain specimens suitable for sale. In both cases, it is those seeds which are well grown and in good condition which must be selected. The fact that good quality seeds can only be obtained from healthy plants should be stressed, and samples compared in the garden.

If possible, a visit should be made to a well-managed farm in the locality where good examples of selected seeds are to be seen, kept in store in a proper manner. At the same time, the methods of seed storage more commonly used locally must be considered. The fact that a tremendous amount of seed is wasted each season, due to inadequate methods of preservation, must not be forgotten.

This series of lessons may be linked advantageously with others concerning certain kinds of insect pests, such as weevils, which destroy the seed crops whilst in store. Methods of preventing the destructive activities of insects may be discussed briefly, but will be considered more fully later. At this stage, it is the effect on the plant products that is to be noted.

Practical work

a. Examine seeds for size and quality. Demonstrate what a suitable seed for sowing looks like, by comparing good samples with bad ones. Use the larger kinds of seeds for this purpose, such as maize, beans, pumpkins, pigeon peas, etc.

b. Try to germinate seeds from (i) plants not yet fully grown, (ii)

plants with weak, unhealthy growth, (iii) plants fully grown and mature.

c. Place some large seeds, such as garden peas, in a dry sealed glass jar. Alongside, place some more in another glass jar in which is some moist blotting paper or cotton wool. Observe the growth of moulds on the seeds, and the fact that some of them show signs of germination.

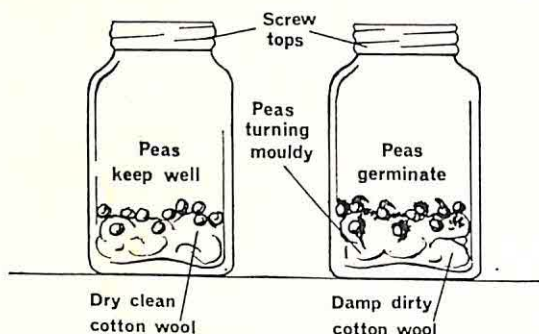


FIGURE 49. Demonstrating the consequences of storing seeds in a damp place

d. Make collections of insects and other pests which are attacking the seeds of plants, either whilst still in the fruit, or amongst the grain after harvesting. Note the damage they are doing, as far as possible, with the aid of sketches (e.g. maize-cobs pecked by birds).

(8) to (10): *After-care of growing plants*

Most of the ideas in this section will naturally be brought out whilst plants are actually being cultivated in the garden. The essential task at all times is to keep the plants growing; once they are checked during growth, they never recover their former condition. During the dry seasons, for example, plants which are at all delicate must be shaded from strong sunlight, and may need to be mulched, or even watered daily. This is not to forget, of course, that certain plants, such as deciduous trees or flowering plants with bulbs, actually benefit from a resting season during which little growth takes place.

The climatic and other geographical conditions which affect plant growth may be studied in connexion with this series of activities. Some plants will not thrive, or alternatively will not flower, if planted at too high an altitude, for example. Similarly, rainfall amounts affect greatly the kind of plants which may be grown in any particular locality. Another factor is the prevailing wind. Often ignored

is the aspect of the site where the garden is situated: planting positions may be hot or dry, cool or shady, exposed to the wind or not, even in the same garden, simply because of the direction in which the land is sloping. Much can be learnt about the needs of plants by observing how well they grow in different positions in a garden.

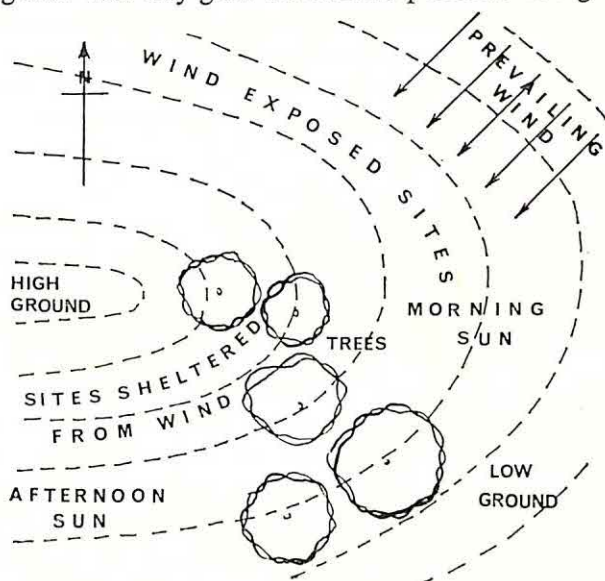


FIGURE 50. Geographical conditions and plant growth

Practical work

- a. Hoeing and weeding are tasks which require constant attention and will form the bulk of the work concerned with the after-care of plants. As this may prove to be laborious to children, only short periods of time should be spent on it with each class, although at frequent intervals, if necessary.
- b. Make a simple rain gauge and keep records of the amounts of rain that fall over a lengthy period of time, preferably throughout the change of season. Which is more beneficial in a garden—short periods of heavy rain, or longer falls of gentle rain?
- c. Make a variety of wind measurement models, such as a wind-vane or wind speed indicator. Record the results on weather charts. (Figure 51.)
- d. Teach that there is a right and a wrong way to water plants. For instance, they should not be watered during the heat of the day, nor should they be watered merely by wetting the surface of the soil or by damping the leaves. The correct way is to give the soil a good soaking,

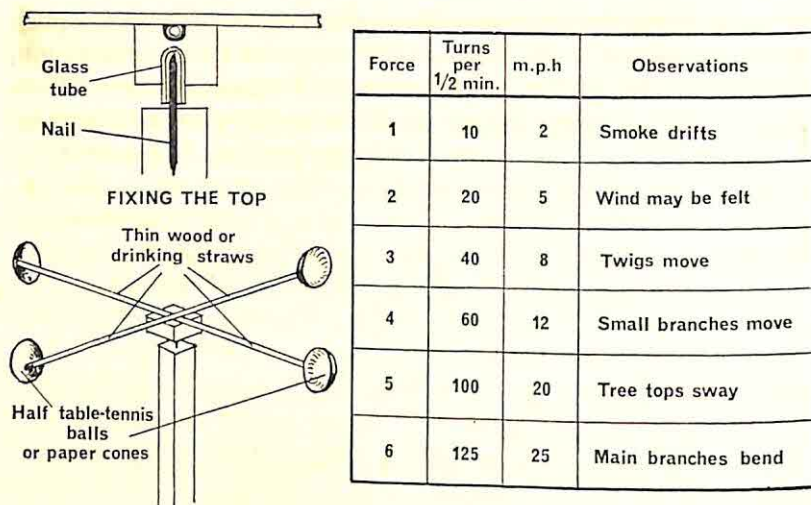


FIGURE 51. A simple model wind speed indicator

without disturbing the roots; and the late afternoon is the best time of day to do it.

e. In the flower garden, it is necessary to see that all dead leaves, old roots, etc., are removed to the compost heap, and not left in the ground to attract pests and disease organisms.

f. Note the effect of overcrowding, exposure to wind, or excessive shade on different kinds of plants. Try to find similar kinds growing in contrasting conditions, and compare them for size and strength. Take note of what is the most suitable spacing for various plants.

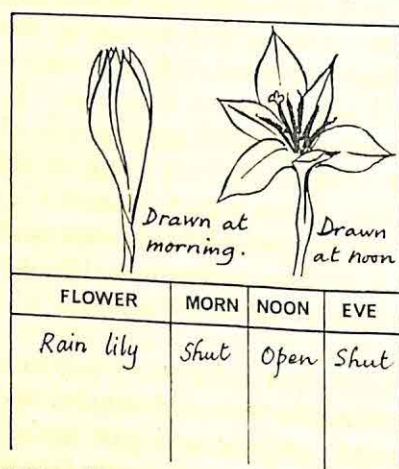


FIGURE 52. Recording a plant movement

g. Compare seedlings grown without thinning with seedlings properly thinned out. When they reach maturity, compare the small long-rooted plants in the unthinned rows, with the well-filled roots on the plants which have been thinned. Do any vegetable plants not require thinning?

h. Make some observations concerning plant movements. For example, take note of any plants with flowers that seem to turn towards the sun and of those with blooms open for only part of each day. Are there any flowers which are only open at night? (Figure 52.)

i. Demonstrate that much water is lost from plants through the leaves. Choose two common shrubby weeds of the same kind (e.g. a wild *Solanum*), about six inches high, and cover (i) a leafy twig of one, and (ii) a twig without leaves of the other, with plastic bags, tied on to prevent air getting in or out. Observe the condensation of moisture in the bag which contains the twig with leaves. How does the moisture pass out of the leaves?

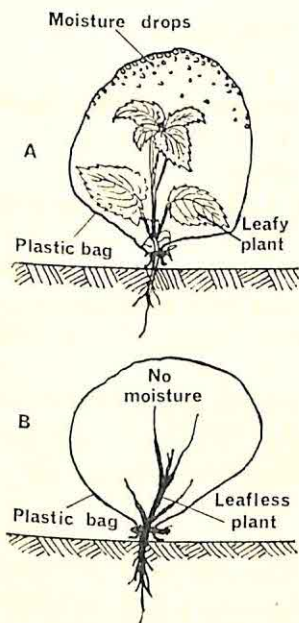


FIGURE 53. Testing for loss of moisture through leaves

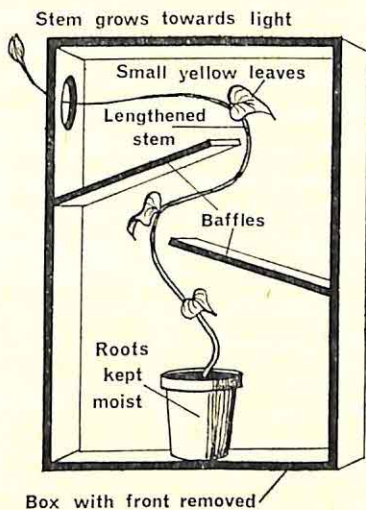


FIGURE 54. Apparatus to show that plants grow towards the light

j. Plants must have sunlight because without it they cannot make food substances in their green leaves. That plants generally grow towards the light can be demonstrated by growing a bean plant in a

box, the only opening in which is a small hole at the top, as shown in Figure 54.

k. Roll a pencil over a green leaf on a sheet of white paper and observe the stain made by the green colouring matter: chlorophyll. Give a lesson on the importance of this substance in relation to food-making by plants.

l. Observe the effect of aspect on plants by noting such objects as the growth of lichens on the 'weather' side of tree-trunks; or the slanting branches of trees which grow in positions exposed to the wind.

PROJECT WORK

Seeds of garden plants. This broad topic may be approached from a great number of angles, of which the following are a few suggestions. They will form the basis of group work which could occupy the children for many weeks of varied activity.

- (i) *Variety in seed formation:* involving a comparison of seeds of herbs, vegetables, trees and shrubs, grasses and cereals; making collections; drawing and recording work. (See Figure 57.)
- (ii) *Development of seedlings:* involving conditions for germination; practical garden work; drawing from specimens; making seed boxes; experiments, etc.
- (iii) *Grain crops:* involving links with geography and history: map work, origin of cereal crops, foods obtained from seeds, grain as staple diet of world communities; reading and writing exercises, etc.
- (iv) *Methods of seed distribution:* involving a study of the world distribution of selected seed plants (e.g. coconut); map work; drawing from specimens; collections; observations and recording, etc.
- (v) *Harvesting and storing seeds:* involving practical garden work; outdoor observations; farm visits; study of pests and diseases of crops; reading and writing exercises; drawing from observations, etc.

As usual, the choice of those which can actually be studied, will depend on local circumstances: only those for which adequate material is available should be included in the project. Nevertheless, teachers should not hesitate in attempting to introduce variety into

their teaching methods. Projects of this kind have the great advantage that they tend to cut across the artificial barriers which exist to the detriment of all subjects in schools.

C. FOOD PLANTS

Main ideas to be brought out

- (1) Most plants grown in a garden for human consumption are called vegetables.
- (2) Vegetable crops are classified as greens, roots, pulse crops, etc.
- (3) Some vegetable plants are deep-rooted; others are shallow-rooted.
- (4) A garden rotation is a series of crops grown one after the other on the same plot of ground.
- (5) Rotations control pests, diseases and weeds; they also help to improve the condition of the soil.
- (6) In a vegetable garden, heavy-feeding crops should alternate with light-feeders, and deep-rooted plants with shallow-rooted.
- (7) Certain plants can be grown alongside each other in the same plot of ground: this is called mixed cropping.
- (8) Crops should be harvested at the correct time to ensure that they are of good quality.
- (9) Crops must be properly cleaned and then graded before they are sold.
- (10) A weed is a wild plant which has established itself unwanted in the garden.
- (11) Weeds grow quickly, mature rapidly, produce many seeds, and are persistent under all conditions.
- (12) Most weeds are annual herbs, but some are shrubs.

(1) to (7): Local vegetable crops

The overall intention in growing vegetable plants in a school garden is not to provide large quantities of produce, but to experiment with a wide range of plants on small plots, as suggested in Chapter 2. This practical activity will provide the opportunity for bringing out the characteristics and needs of each type of vegetable.

The most important food plants in tropical countries are those known as the *cereals*: rice, millet, maize, sorghum, etc. As these will commonly be grown on farms near to the school, it is likely that their

features will be well understood, and not much time or garden space need be given over to their cultivation. It is certain to be necessary, however, to teach the dangers of overcropping the land with the continual growing of these kinds of heavy-feeding plants.

Another group of vegetable plants which take much out of the soil are the *Green crops* (e.g. brassicas such as cabbage and spinach). It is for the leaves, generally, that they are grown, and it is because of the food which the plant stores in these parts that they are such valuable vegetables. Brassicas are usually started in a seed-bed, and because they are heavy feeders, require transplanting later into rich soil which is not sour. It is important to keep them growing, and their roots pressed down firm in the soil.

The *pulse crops* are an important group of vegetables, not only because of the many plants which belong to it (e.g. peas and beans, grams, lentils, etc.), but also because of the fact that the roots of these plants carry nodules containing bacteria which enrich the soil by increasing the nitrogen therein. The characteristics of the legume family, of which all the pulse crops are examples, are well-known; and mainly because of their distinctive flowers and three-lobed leaves, are easily recognized. Light, rich soil, kept moist, is ideal for these.

Plants belonging to various plant families produce edible *roots*; and one of the most important, the turnip, is actually a brassica. Other kinds are cassava, yam, sweet potato, and carrot, beet, arrowroot, etc. Good, deep, open soil is best, and fresh manure is never wanted, as its presence affects the uniform development of the roots.

Pumpkins, gourds, melons, etc., all belong to another interesting family: the *Cucurbits*. With their large soft leaves and stems, creeping habit of growth, orange or yellow flowers with the pollen and the ovules forming on different flowers on the same plant, and large juicy fruits, they are well-known and common. These plants are again heavy feeders which require plenty of moisture in the soil. Nevertheless, they are unsuited to a very moist atmosphere as the leaves and stems are liable to fungus infections. This can be observed in the form of a grey-coloured mould all over these parts of the plant.

Other plant families which include edible types, are the *Solanums* (egg plant and potato), and the *Lilies* (onions, garlic and shallots). The characteristics of these and of other plants, may be brought out in ways similar to the above, whilst practical experience is being gained in growing them.

Observe the systems which may be used by local farmers of alter-

nating their crops on each plot of ground. The idea of rotations may also be introduced by considering the age-old methods of 'shifting cultivation' which were themselves simple forms of rotations, whereby the ground was allowed to rest after intensive cultivation. This should lead to the idea that rotations are very ancient, and that modern systems have developed out of those used previously. The need to alternate plants which have differing soil requirements, and the importance of including a root crop in the rotation, as well as the value of leguminous plants as a means of restoring fertility, are further points of equal importance.

Practical work

a. On the four plots kept for vegetable plants in the garden, lay out a simple four-course rotation as follows:

Heavy-feeders; roots; light-feeders; legumes

A few rows of different varieties of each kind of vegetable should be tried. How have these different varieties come about? What are the advantages of each?

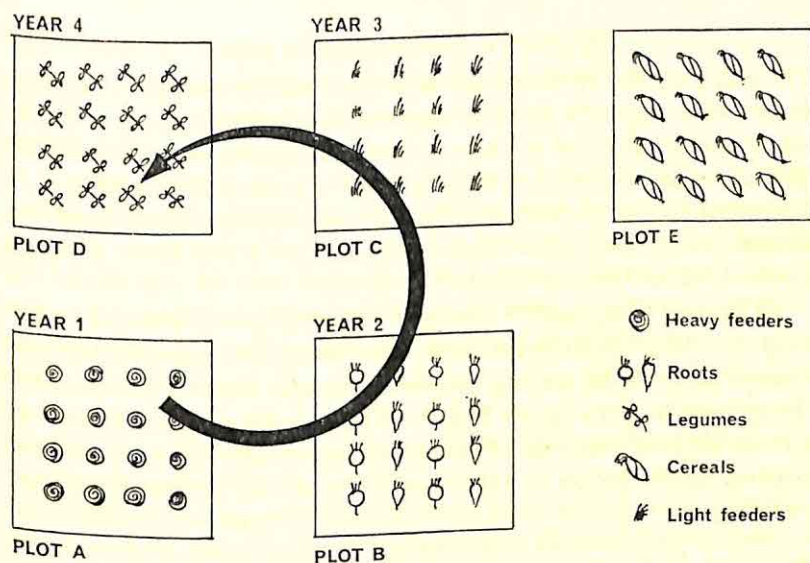


FIGURE 55. A rotation plan for the garden

b. Establish a fifth plot alongside the rotation, on which one kind of cereal is grown every season. Compare the yields obtained after

keeping careful records over a period of time. What is the effect on the soil of the continuous cultivation of the same crop?

c. Experiments can be made on various plants grown for green manure. Any leafy plant, which grows quickly, preferably sown together with a leguminous plant, will be suitable to be dug into the soil. This should be done before the plants go to seed. Check the effect on plants grown on this plot in subsequent seasons. Does the soil hold moisture longer in this plot than elsewhere?

d. The effect of rotations on pests and diseases should be noted. Demonstrate that the frequent cultivation of the soil, and the change of plants that a rotation necessitates, interrupts the life cycles of other organisms, and thereby limits their activities and consequent damage of garden plants.

e. In many tropical lands, different kinds of food plants are often grown alongside each other in the same plot. This method may be tried in the school garden, but it should be pointed out that not all plants grow well together. Those which make the same demands on the soil are not suitable for mixed cropping in this fashion; whereas good examples are potatoes and maize; beans and cabbage; onions and beetroot. Discover local examples.

(8) and (9): Harvesting food plants

There is a correct time and procedure for the harvesting of all crops grown in a vegetable garden, and decisions in this respect may be made during practical work as the crops reach maturity. Plants such as the brassicas should not be left in the ground too long, and must be harvested before they start to go to seed. On the other hand, the cereals must have their leaves withered and the seeds properly ripened before they are finally harvested.

At harvest time, there is always the need for good habits of garden hygiene. After green crops have been lifted, for example, the root stumps ought to be dug up and composted or burnt, and not left in the ground to grow again. Finally the plots should be dug over and left as tidy as possible after harvesting, ready for next season's sowing. Local habits in this respect should be observed for comparison.

Practical work

a. Compare produce of different quality. Use examples of locally-grown crops, both good and bad, to teach the idea that high quality is important if a gardener is to be able to sell his produce satisfac-

torily. Stress that crops should be harvested when they are ripe, but not over-ripe. Point out that size and healthiness are signs of good quality.

b. Demonstrate the cleaning of a crop. Use a suitable grain crop, and after harvesting demonstrate how particles of soil may be removed; also any diseased seeds. Refer to the 'winnowing' of the chaff from the grain by the wind. Stress the need for the cleaning of soil particularly from root crops.

c. Use a root crop to show how produce may be graded for size and quality. Reject all old roots, those undersized or misshapen or otherwise damaged.

(10) to (12): *Weed plants of the garden*

The kind of problem to be solved in this section will be raised by asking questions such as, 'What are the main differences between a weed and a cultivated plant?', 'Are all weeds annual herbs?', 'How are weeds kept out of a garden?', and 'Do weeds harm other plants?' Answers may be obtained as a result of practical exercises as suggested below, together with the investigation of the general characteristics of weed plants.

Practical work

a. Study the wide variety of weed plants, using examples such as nut grass (a sedge); bracken (a fern); couch (a grass); and *Lantana* (a shrub).

b. Demonstrate the use of the hoe for the eradication of small weeds from flower and seed-beds in the garden; and emphasize that such a task must be continued all the time. Observe the effect on the choking of delicate garden plants by the more vigorous weeds.

c. Take samples of soil from the garden and search in them carefully for weed seeds, using a hand lens. Place some of the soil in a large square tin. Water for a few days until any seeds that it contains have germinated, then count the number of seedlings. After measuring the area of the soil surface in the tin, calculate the number of weed seeds per square yard of garden.

d. Carefully protect a herbaceous weed seedling (e.g. wild mustard), and record its rate of growth by measuring its height above ground daily. How many days does it grow before seeds form?

e. Collect all the fruit of one particular weed plant, such as the wild mustard again, and calculate the number of seeds produced each season.

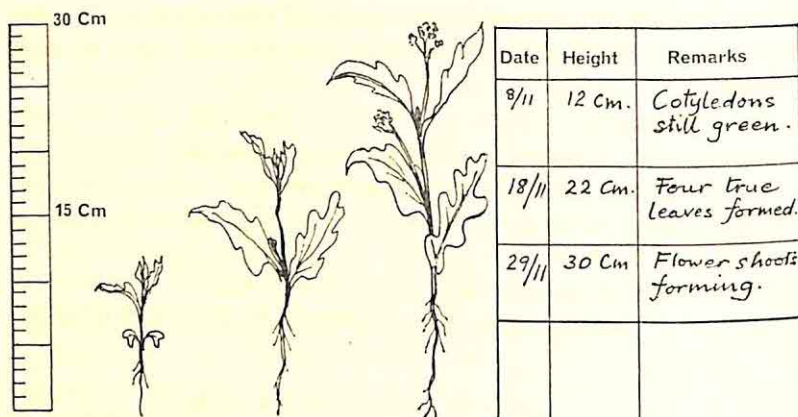


FIGURE 56. Comparing the rate of growth of weed plants

f. Compare the different methods of seed dispersal found in weed plants common to the garden; similarly, observe underground methods of self-propagation, such as the numerous tiny tubers of *Oxalis*.

PROJECT WORK

As the simple experimental work with vegetable plants, as suggested above, itself amounts to an extensive project, there is no need to elaborate it further here. The study of *Weeds*, however, may be undertaken profitably by means of the project method.

After the usual introductory lesson, during which the class will be grouped, pupils will be provided with collecting equipment, including tins, bags for seeds, paper and boards for pressing plants. Work cards

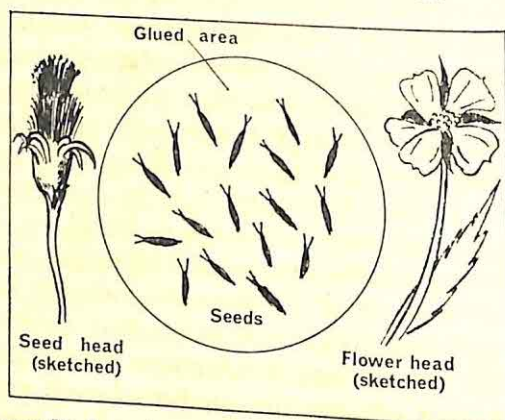


FIGURE 57. A method of mounting seeds on a display card

would then be given out indicating the particular aspect of the topic which each group is to study, and the area in which they are to work. It is suggested that each deals with one of the main characteristics of weeds, which are:

- (i) Rapidity of germination and quick establishment.
- (ii) Speed with which they reach maturity.
- (iii) Production of numerous seeds.
- (iv) Efficient modes of vegetative reproduction.
- (v) Persistence under poor conditions.

The principal activity will be the collection, pressing and mounting of specimens; seeds may be collected separately and mounted on gummed squares of paper, and all will be fully labelled, in the customary manner. The teacher's function will be to control the whole project, and see that the main points are elaborated by means of simple experiments as suggested in the practical work above.

D. FARMS AND FARMING

Main ideas to be brought out

- (1) Schools in tropical lands are generally situated in either pastoral country or in a mixed farming area.
- (2) A ranch is a large enclosed area of pastoral land; livestock on a ranch are usually kept for the production of meat.
- (3) Cattle on mixed farms are usually kept for dairy purposes.
- (4) On all farms the land must never be over-stocked; neither must it be over-cropped.
- (5) Most farming necessitates buildings erected for particular purposes.
- (6) Some farm implements are fixed inside farm buildings.
- (7) Many different tasks are required on a farm; craftsmanship is the basis of all good farm work.
- (8) A boundary fence to a farm requires to be stock-proof.
- (9) Fence posts must be of resistant material and properly spaced.

(1) to (4): A local farm study

This section is concerned with the factors governing the choice of the farming system most common in the school locality. Because of the differences in the climate, altitude, slope of the ground, etc., the same kind of crops, or the same kind of animals, are not always equally suitable everywhere. The study will begin with a visit to the chosen local farm, with the object of trying to discover what determines the

system in use. In tropical lands, the most important methods likely to need to be considered in detail are ranching and mixed farming, and some notes on the main points of each of these systems, to bring out during the course of the work, are included below.

The tradition in most pastoral areas of tropical lands is for privately owned livestock to be grazed on communally held land. With the increasing pressure of the population of both humans and livestock, more and more of such land is becoming enclosed into large blocks, to be farmed on a ranching system. As these farms are found in rather dry areas, where there are perhaps few rivers, it may be necessary to dig water-holes, or sink wells. As ranching land is never cultivated, the natural grasses must be conserved, and successful farming of this type depends principally on the number of livestock never being permitted to exceed that which the land can support without detriment to the plant life.

In a district where cultivation is possible, the most usual type of farming is one in which the growing of food crops is alternated with the grazing of animals. These two activities may take place in turn, on the same part of the land; otherwise, the total area may be divided into two, and the grazing and the cultivating kept separate. Whichever method is adopted, it is called mixed farming. It has the great advantage that the dung from the animals is available to replenish the soil after cultivation. The cattle on such a farm are usually there to be milked; and as the principal food of cattle is grass, some of the land on a mixed farm will be allocated to this crop. Since dairy cows are required to produce large quantities of milk, however, they must have additional food, particularly at certain times of the year when the grass is scarce; and this will mean that another part of the land must be used for the growing of fodder crops. These plants may be alternated with temporary grass in a rotation, or grown on plots specially put aside for the purpose. In any event, it will be found that the land will probably be well paddocked, as this is the only effective way of controlling the grazing habits of the cattle. These points are considered in greater detail in later sections.

The study of a local farm, of whatever type it may be, is best handled by means of the project method, and further details in this respect are included after the next two sections. The main object will be to discover why a particular method of farming has been adopted, and then examine the principles on which the successful use of the system depends. To assist this process of inquiry, on the initial visit

to the farm, pupils may be asked such questions as 'What does the farmer do to the soil to keep it in good condition?', 'Why does the farmer only keep cattle and not grow crops?', or 'How is the grass-land on this farm kept in full production?'

(5) and (6): *Farm buildings and equipment*

As the buildings a farmer needs are dependent on the kind of farming activity which he is able to undertake on the particular land in his possession, this topic is closely related to the previous one. There are a number of aspects of the topic which may be investigated. These are elaborated in the section later on Project Work, but should include the materials of which farm buildings are made; dimensions and sizes related to overall needs and function; roofing methods; the comparative value of temporary or permanent buildings; and the value of particular building materials, such as timber and concrete.

Similarly, the fixed equipment to be found inside many farm buildings should be examined. These may include dairy equipment, and possibly in the more developed areas, a cream separator or a milking machine; containers for holding foodstuffs in store; a grain mill; water supply pumps and engines. What is the source of power for the engines? What materials are used in their construction?

(7) to (9): *Farm craftsmanship*

This is a much neglected topic, yet a very important one. It is true to say that a well-kept farm, on which there is evidence of good manual work being done, is likely to be an efficient one. Most tasks concerned with gardening and farming necessitate manual work, and it is therefore necessary that people are skilled in this way. From an educational point of view, it is part of the process of learning to appreciate that a job well done gives satisfaction; and that if a task does not do so, it can have little real educational value.

Practical work

a. There are certain objects to make connected with gardening which will enable pupils to develop manual skill, e.g., small tools, such as dibbers, waste pans, plant labels. The teacher should concentrate on design and the provision of the necessary tools and materials, and not be concerned overmuch with the pupils' technical skill initially, however, as this will improve with practice.

b. The erection of a permanent post and wire round part of the

garden boundary is a task which will involve the whole class. If the money is available, a small section could be completed every year by a different class. It will need to be done well, if the fence is to be strong, efficient and look good. Small groups of pupils may be set particular tasks to complete. For example, deciding on the alignment of the fence; digging post holes; preparing the timber posts; stretching the lengths of wire, etc. It is preferable that plain, rather than barbed wire is used by children as this latter can be dangerous.

c. The construction of seed-boxes, banana-leaf plant pots, and wire baskets to hold plants, the erection of shade huts, compost boxes and houses for small livestock, are other objects which can be made in the

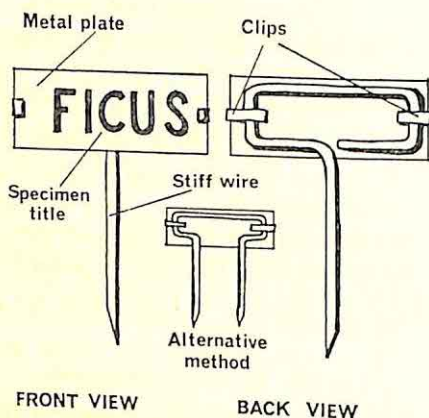


FIGURE 58. One method of making strong plant labels

school, if a teacher has the enterprise and the necessary minimum of woodworking tools and materials at his disposal.

d. Craft work of a certain kind will be involved, whenever any of the common garden tasks related to plants or the soil are undertaken. It is important that these are completed with just as much care and thought, as when doing woodwork. Examples are trimming hedges; pruning fruit trees; planting cuttings or other material for vegetative propagation; even simply digging the garden will necessitate skill, if it is to be efficiently done and worthwhile.

PROJECT WORK

The study of a local farm, including its buildings and equipment, may be combined as a project. During a preliminary general discussion lesson, pupils would be grouped, as usual, and given their

task cards. These might take the form of questions related to particular aspects of the topic, as follows:

<i>The farm</i>	How large is it?
	On what kind of soil is it situated?
	Is the land paddocked?
	Are animals kept on the farm?
	What kinds of plants are cultivated?
<i>The plants</i>	From where does the farm get its water?
	For what purpose are the crops grown?
	Are there any plants grown as fodder?
	Is there a rotation of crops?
	Are there any trees on the farm?
<i>The animals</i>	What is the effect of the trees on grassland?
	How are weeds kept under control?
	What kinds of livestock are on the farm?
	What is their purpose?
	What quantity of each kind are there?
<i>The buildings</i>	By what system are the young ones reared?
	How are the animals housed and fed?
	In what way is disease kept under control?
	What is their function?
	Are they permanent or temporary?
<i>The equipment</i>	What materials have been used to build them?
	How are they made rigid and strong?
	How are their sizes related to purpose?
	How are they ventilated and made rain-proof?
	For what work is the equipment designed?
	What mechanical principles are involved?
	What is the source of power on the farm?
	Are any of the tools fixed in position?
	What materials are used in their construction?
	How is produce transported from the farm?

The project will be based on a series of visits to a suitably chosen local farm. All observations should be recorded and entered into pupils' field-work notebooks, and then unified within the groups later, in the classroom.

An interesting and entertaining activity to follow the outdoor part of the work, is for the groups to construct small models of the objects they have seen, using such materials as cardboard, match-boxes, pieces of wood or tin, etc. If all the models are made to approximately the same scale, they may be arranged together finally as a complete model of the farmstead.

Alternatively, a number of group folders may be completed, as shown. All the pupils will contribute towards the filling of the pages with different kinds of work, such as graphs made from simple

statistics; drawings, either from 'life' or as 'memory pictures'; written descriptive passages, or imaginative stories with titles such as 'A day on a ranch', 'Grinding the corn', or 'Bringing in the cows for

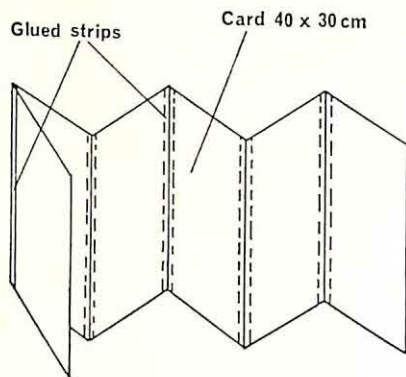


FIGURE 59. How to make a folder

milking'. To complete this work, all the pupils could compete for the outer cover designs for each folder, the ones considered by the teacher to be most suitable being selected.

E. FARM CROPS

Main ideas to be brought out

- (1) All grasses have names and we can learn to recognize them.
- (2) Because of their spreading habit of growth, grasses form a turf.
- (3) The mixture of grasses and weeds in a turf is called a sward.
- (4) Many grasses are unpalatable and are therefore unwanted in pastures.
- (5) Some herbs in grassland are useful weeds; others are poisonous to livestock.
- (6) A paddock is an area of grassland surrounded by a hedge or fence; careful management is required to keep paddocks in good condition.
- (7) Poor grassland may be improved by manuring and replanting.
- (8) Overgrazing will cause the sward to deteriorate.
- (9) The burning of grass in the dry seasons will produce a flush of young green shoots, but may lead to soil erosion.

- (10) Alternate husbandry is a system of farming whereby crops and grass are rotated each season in the fields.
- (11) Farm rotations improve the quality of the crops and the condition of the soil; they also help control pests and diseases.

(1) to (3): Useful grasses

The aim of this section is to enable pupils to distinguish between those grasses which are valuable in pastures and those which are weeds. First of all it should be taught that grasses must be thought of as cultivated plants, just the same as other farm crops. The general characteristics of grasses will need to be revised, noting specially the spreading root formation, the leafiness of the plant, the wind-pollinated flower-head, and the particular seed formation: the grain. Various grasses should be compared without reference to the flowers at all, however, as they can be recognized in this state, even when grazed close to the ground.

Practical work

- a. In the school garden, grassed areas around buildings should be kept neat and tidy and cut close. The edges of lawns must be trimmed occasionally. Weeds will need to be dug out without leaving their roots in the ground, and bare patches in the lawn replanted as they appear.
- b. Draw specimens of a grass in order to revise the main features important as a means of recognition, e.g. leaf form, including blade and sheath; inflorescence; appearance of the florets; root growth.
- c. Make a collection of grass plants which are important from an agricultural point of view. Plant roots of these in rows in a plot of ground, or alternatively, sow the seeds. Specimens of the mature plants may be pressed between sheets of newspaper until dry, and then mounted on large pieces of white paper. Alongside should be written all available information, as usual.
- d. Observe the formation of a turf. Choose an area of grassland which is well established and note how the roots of the grass plants form a dense 'mat' just below the surface of the soil. Compare this with the roots of grass plants in a newly formed turf. Dig up some roots and examine the 'tillering' habit (i.e. spreading by means of new root and shoot production as the plants are grazed or cut).
- e. Whilst on a farm visit, try to discover which grasses are liked by grazing animals and which are left alone. Do all kinds of farm animals eat the same kinds of grass plants?

(4) and (5): Weeds of grassland

In practice, this topic will be closely related to the previous one, because weeds are present in most pastures. Such weeds may be wild grasses, or they may be broad-leaved herbs. Grassland is often invaded by shrubby weeds. Outline the common characteristics of pernicious specimens of this type, such as Sodom apple (*Solanum*) or *Lantana*. Discuss local methods of eradication. Is cutting effective? If so, at what time of the year should this be done? Mention the idea of weed-killers: chemicals which can be safely sprayed on grassland to kill unwanted plants growing in it. Do the weed-killers affect any of the grass plants at all?

Practical work

- a. Make a collection of grassland weeds. Classify them according to their botanical families as far as possible. For example, legumes, composites, grasses, etc. Which plant family contains most weeds?
- b. Observe the degree to which weeds are restricting the growth of garden plants. Which kinds are most common both in the school garden and on local farmland? Revise the characteristics which enable them to be so successful. What can be done to control them? Do any of them persist for more than one year?
- c. Experiment with the idea of digging up poor areas of grassland and sowing or replanting direct new grass plants, after burning all weeds and applying compost to the soil. Similarly, top-dress a small plot of poor grass with compost or animal dung in the wet season, and observe the effect on the growth of grass. Does manure bring more weeds?
- d. By questioning local people, try to discover which pasture plants are considered to be actually poisonous to farm animals. Teach their characteristics and the necessity to avoid them ourselves.
- e. A study may be made by collecting and examining those grasses which are useful for purposes other than as food for livestock, for example, as material for thatching, or for mulching.

(6) to (11): Caring for grassland

Schools in rural areas of tropical lands are often built on comparatively large plots of ground. As it will not be practicable, or desirable, to cultivate much of this land, that which is not required for the garden plots, should be grassed over, to be grazed by livestock. For this purpose, it is advised that schools should not possess their

own cattle or sheep; but should come to some arrangement with a local farmer, probably the parent of a school pupil, who will be prepared to bring his animals along as necessary, to keep the pastures grazed. The principles of grassland management may thus be brought out.

There are three methods in common use of controlling grazing animals: (i) herding them with the aid of boys or dogs, (ii) tethering them, and (iii) dividing up the whole area into paddocks. The disadvantages and advantages of each will provide material for discussion lessons based on outdoor observations.

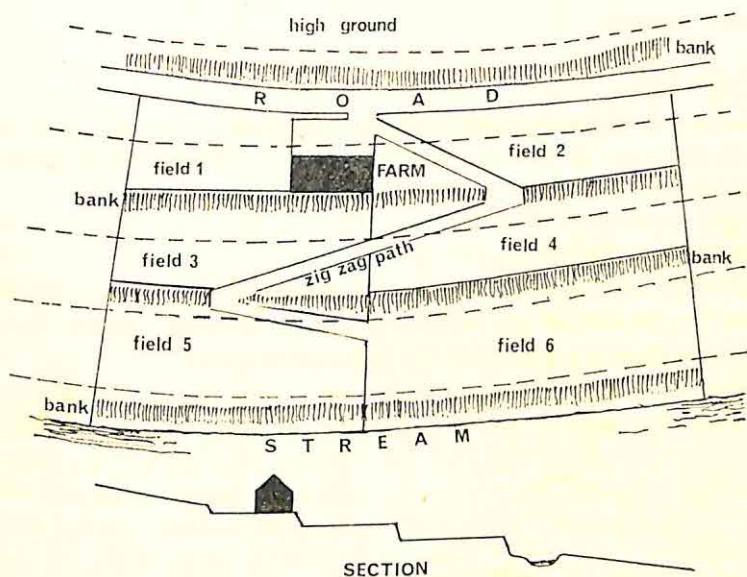


FIGURE 60. A terraced and paddocked smallholding

Consider the idea of grazing the land in rotation, the animals being moved from one paddock to the next in succession. Point out the benefits of spreading over the fields the dung left behind by the livestock, to maintain fertility.

On mixed farms, grass is sometimes sown in fields which have previously supported crops of other kinds, and which is intended to be dug up and replaced by such crops in the future again. This method is called *alternate husbandry*, because the grass and other crops follow each other in succession round the fields. The areas of temporary grass thus included are called *leys*, and the whole series of crops becomes a farm rotation.

Farm rotations may be compared with those used in the garden. Also, a more detailed outline of the history of rotations may be attempted, as this topic leads to an understanding of the development of agriculture throughout the ages. The manner in which rotations have always been closely related to the food needs of a community is the fact to stress. An example of this is that in Britain, although the earlier farm rotations only included a one-year ley, in later systems the ley was lengthened to as much as eight years in some parts of the country, as milk production became more important—grass being the main food of cattle. Information on where to find examples of leys being used in local farming systems, may be obtained from agricultural officers.

Practical work

- a. If the school grounds have not already been paddocked, have an out-door lesson to consider the way in which this might be done. Bear in mind such facts as suitable sizes for each plot, slope of the ground, accessibility to roads, buildings, etc. Is any of the land too steep to be paddocked?
- b. Observe land near to the school which has been over-grazed. Compare the kind of grasses to be found on such land with those on grassland properly managed. Are the dominant species still palatable ones?
- c. Experiment with the burning of a small area of grassland in the dry season, taking care to keep it under control. Observe late the flush of bright green shoots which follow the rains. Are any plants eliminated by the burning? If possible, visit a place where burning has caused erosion.

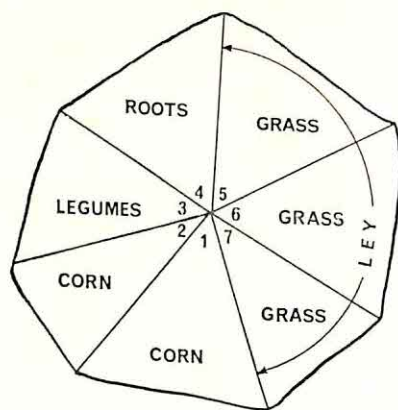


FIGURE 61. A grass ley included in a farm rotation

- d. Examine leguminous plants of grassland for nodules on the roots, and revise their significance. What is the survival value of legumes in pasture? i.e. are they more common in new pastures or in older grassland?
- e. In the school garden, the meaning of 'ley' may be taught by estab-

lishing seven small plots in place of the four suggested in the section on 'Food Plants' in this chapter. The additional three plots would be planted with a suitable shallow-rooted grass, such as a species of *Chloris* or *Cynodon*, and rotated with the other crops. It will be observed that each plot remains under grass for three seasons at a time. f. The idea of alternate husbandry may be taught in the classroom by using a model farm divided into paddocks. Cut out square pieces of

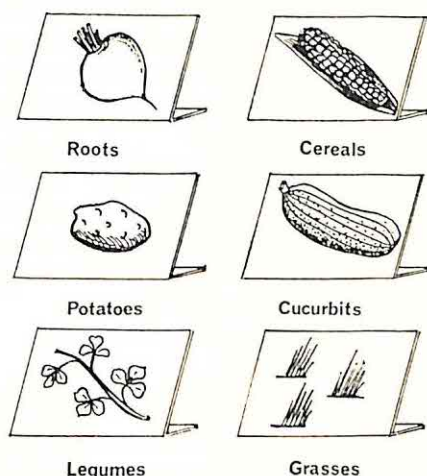


FIGURE 62. Suitable symbols to use on labels for a farm rotation model

card, and on each write the name of a farm crop, or draw a symbol to represent the crop, and include two or three cards for the grass leys. Place all on the model farm, one in each paddock. Move them in succession round the farm to represent the changes in cropping that take place on each paddock season by season.

PROJECT WORK

As an alternative to a project planned from a wide point of view as before, in this case three group activities of a more specialized character are proposed.

A. *The variety of plants in a sward.* Select a small area of the surface of a grass field and give a few children the task of comparing the variety of plants found growing within it. A wire frame, about three feet square, is a useful aid for this: it may be placed at random on the sward, and all the plants it encloses may then be collected. Other groups of pupils may be allotted similar-sized areas of grassland situated elsewhere. Each group will decide on the dominant species

of plant in their collection. To continue the project, facts about the plants and the area studied may be recorded in answer to questions such as, 'Is the soil under the grass light or heavy, water-logged or well-drained?', 'Are the plants mainly grass or mainly weeds?' or 'Has the field been used for the grazing of livestock recently?'

B. *Leguminous weeds of grassland*. Plants belonging to this important family often establish themselves in pastures. Examples may be herbaceous (e.g. clover), or shrubby (e.g. *Crotalaria*). Divide the class into two groups, each to study plants with one of these habits of growth. Make collections of leaves, roots and seed pods of these plants, as well as the flowers, which may be drawn. Bring out the special value of these plants as regards soil fertility, and the usefulness of some of them as food for livestock. 'On what kind of soil do leguminous plants grow best?' is the kind of problem to set as a basis of observation.

C. *A comparison of temporary and permanent grassland*. There are advantages and disadvantages with either of these methods of cultivating grass on a farm, and they may be compared with benefit, taking the practical problems related to the up-keep of each, as the basis of study. One set of pupils could deal with each of them:

- (i) In what way may all parts of the farmland be made to benefit from the dung obtained from farm animals?
- (ii) What is the best way of ensuring that grassland soil maintains an adequate humus content?
- (iii) How can weeds and diseases of farm crops be kept under control?
- (iv) How can the best use be made of steep land on a farm?
- (v) In what way do rotations keep farmland in full productivity?
- (vi) Can the farm animals be supplied with water in every part of the farm?

F. FARM ANIMALS

Main ideas to be brought out

- (1) Farm animals must be treated with kindness and care.
- (2) Farm animals are domesticated; they are therefore dependent on human beings for their welfare entirely.
- (3) Livestock require proper housing, food and water, and protection from pests and diseases.

- (4) Chicks may be reared from a sitting of fertile eggs under a hen; eggs must be chosen for size and fertility.
- (5) After hatching, chicks need special care and attention to enable them to grow healthily and rapidly.
- (6) Pigs, poultry, sheep, goats and cattle are the most important kinds of farm animals; there are many different breeds of each.
- (7) Meat, dairy produce and wool are the chief products from livestock; they also yield valuable skins, hair, etc.
- (8) There are definite names for the various age-groups of each kind of farm animal; and different names for animals of either sex.
- (9) Most wild birds on the land are harmless, but a few kinds are pests.
- (10) Most wild mammals are pests in a garden or on a farm.
- (11) Many other kinds of small animals are to be seen on farmland; some are harmless, but others are serious pests.

(1) to (5): Care of small livestock

Practical work

This is an exercise for the whole class which should be carefully organized as group work, lasting over a whole term. The aim is to rear a number of chicks from a sitting of eggs, under the care of a broody hen (one that has ceased to lay and persists in sitting on the eggs). At the outset, it will be essential to make sure that the required number of good quality eggs will be available at the start of the term, and that a suitable hen can be obtained locally. The only necessary equipment will be a small hen-coop and a wired-in enclosure, as well as a few simple cleaning tools, and containers for food and water.

The best way of organizing the group work, is to give each a daily task for about a week at a time. The class should keep a special 'livestock book' for the recording of the tasks as they are completed each day, as it is by such a method that good habits will be encouraged and the correct attitude formed towards the care of animals in general. The daily responsibilities will not be many; but will include feeding, watering, cleaning and replacement of bedding, litter, etc., and protection against pests. Maintenance of housing and other equipment will need attention, which may involve pupils for longer periods of time.

It should be remembered that there is no place in a primary school

for the keeping of livestock commercially. The purpose is educational, and that is why the activity outlined above is not planned to extend beyond the limit of one term. The chicks will hatch out after twenty-one days; and by the end of the term should be approximately two and a half months old, and will be ready to be separated from the mother hen and sold. This will bring in some cash towards the cost of replacements for the following year.

Whilst being an opportunity to bring out the facts related to the basic needs of all domesticated livestock, as well as many of a general

DATE	REMARKS
12/9	<u>Goals</u>: Replaced old bedding with clean litter. Whitewashed walls of house. Moved tether to new plot of grass. <u>Poultry</u>: Tested eggs for fertility - one only addled. Dusted hen with insect powder. Increased layers food ration to 4oz. each bird per day.

FIGURE 63. Entries in the livestock book

biological nature, certain ideas specifically related to poultry will be made clear, and these should include:

- (i) that a hen will care for the eggs, turn them and keep them warm; but she will require food and water, morning and evening, and the opportunity to have exercise.
- (ii) that the young chicks after hatching will be taught to feed by the hen, but must be given food of a suitable kind and size, together with grit and water.
- (iii) that chicks need sunlight and green food, and the chance to get plenty of exercise in adequate, well-protected space.
- (iv) that insects and other creatures can be serious pests of small chicks, and it is essential that houses in which poultry live should be kept clean, well-ventilated, and made secure at night.

(6) to (8): *Facts about farm livestock*

The different kinds of domesticated animals will, by this time, be well known. This series of lessons, therefore, should be considered as a continuation of work begun in previous years, but will now introduce the essential facts about the particular *breeds* of each kind of farm animal.

The local breeds may be considered to begin with, making special reference to their physical characteristics and their uses. Later, comparison can be made with a wider variety of breeds, including those introduced from overseas to improve indigenous kinds. By means of a collection of good clear illustrations, preferably in colour if they can be obtained, this topic will be made more interesting.

Livestock are bred either to yield produce, which may not necessarily be food, or to do work. Each breed represents a considerable degree of specialization. For example, considering first those which are intended to produce food, some pigs are bred for pork and others for bacon. Cattle are bred for beef production or for milking purposes. Similarly, there are poultry which are specialized for egg-laying and these may be compared with table breeds. A sheep may be of a kind which has been bred to produce mutton of good quality; but many other breeds of sheep are important on account of their wool-producing qualities.

Farm animals produce other commodities than these, of course, and the most important are the skins and hides, bristles, and certain oils and fats. The waste from animals, such as horns and hoofs, may contribute to their usefulness on the farms, being needed for the manufacture of fertilizers; and the importance of animal manure should not be forgotten. No animals are bred specifically for these products, however.

The breeds of livestock of the types referred to above, which may be seen in the school area, should be studied from this functional point of view, being classified according to the most important kind of produce they yield. If breeds of other kinds of livestock are more common locally, such as working oxen, camels, donkeys, mules and horses, they may be considered in a somewhat different manner. In these examples it is the work they do that is important, and it is from this point of view that they ought to be investigated.

Practical work

a. The characteristics typical of each important breed of domesticated animal should be known. These may be pointed out practically

whilst visiting farms and actually handling livestock. Alternatively, the teacher could make use of pictures to refer to the good points of breeds not seen locally. Pupils may make their own illustrated notes, comparing the breeds of each type (of dairy cattle or bacon pigs, for example).

b. Visit a local butcher and learn about the various parts of an animal used for human consumption: pupils to acquire the names of the 'cuts' and build up a vocabulary. In the classroom, mark out an outline diagram of the animal concerned.

c. In some areas it may be possible for pupils actually to see milking being done efficiently, if not to take part and practise themselves. Such facts as the need to avoid pulling the teats whilst milking, or getting the hands wet in the milk, are proven principles seldom appreciated in rural communities of tropical lands.

d. Teach the importance of clean milk production by means of a demonstration. Obtain a quantity of milk straight from a cow and divide it into four equal parts; put these in clean glass bottles labelled (a), (b), (c) and (d). Place (a) in a bucket of cold water or submerged in a nearby stream; (b) in a position exposed to full sunlight; (c) on the table in the classroom uncorked; and (d) in a similar position, but with a spoonful of dirty water added. Compare the condition of the milk in the bottles after twenty-four hours. What is the effect of temperature and dirt on the keeping quality of milk?

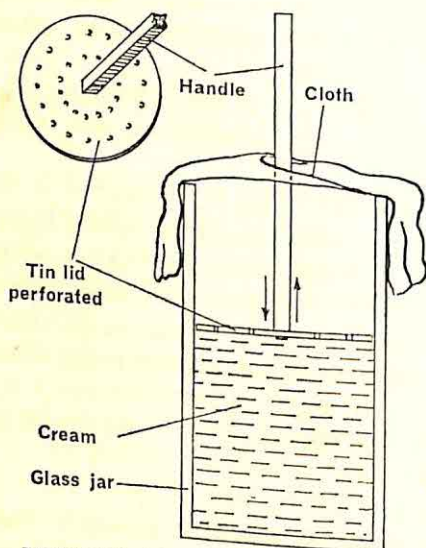


FIGURE 64. A home-made butter churn

- e. Do some practical work related to dairy produce. Make a simple 'butter churn' out of a tin lid, a stick and a glass jar, as shown. By plunging the perforated lid a number of times into the cream in the jar, it can be made to form into butter. It is possible from this to calculate the percentage of butter-fat in the milk. (Figure 64.)
- f. Give a lesson on cheese, stressing that it is a food made out of the protein content of milk. Leave some milk standing until it curdles (the protein separated from other substances in milk is called the curd, the remainder being the whey). What has caused the milk to change in this manner? To another sample of milk, add a small quantity of vinegar to get the same effect.
- g. Make collections of the wide variety of objects which have their origin in produce from farm livestock. Encourage children to use pieces of leather to make small bags or purses, for instance. Explain to them how leather is cured.
- h. Many animals will be seen doing work for farmers, such as the water-buffalo, bullock, mule or donkey. Try to find out what work they are doing, and discuss whether to use these animals is the most efficient way of getting the tasks completed. Why have animals been replaced by machines in many lands as a source of power on farms?
- i. Animals of different ages and of either sex usually have particular names within each kind of domesticated livestock. For example, the

SEX & AGE GROUP	CATTLE	SHEEP	GOATS	PIGS	FOWLS
Adult male	Bull				
Adult female	Cow				
Young offspring	Calf				
Young male	Bull calf				
Castrated male	Steer				
Young female	Heifer				

FIGURE 65. A chart for tabulating livestock sex and age-group names

young female of all breeds of cattle is called a heifer, and a young female pig is a gilt. A study can be made of the six important age-groups which are (i) adult male, (ii) adult female, (iii) young of both sexes, (iv) young male, (v) castrated male, and (vi) young female. Drawings or cut-out pictures of representative animals of these

age-groups may accompany descriptions. These may be mounted on large pieces of card to form a display. (See Appendix A for definitions.)

(9) to (11): *Wild life on a farm*

This is again a continuation of work begun in earlier years, but is a topic which will form a constant source of interest and become a major activity in rural science lessons. The practical work concerned with the control of wild life in the garden will give many opportunities for observation and discussion whilst out-of-doors. Collections should be continued, and full use made of the nature table, and links established with as many other subjects as possible, through drawing, writing and oral work.

B I R D C H A R T				
Date	Description	No.	Locality	Feeding habit
7/6	Red and Green climbing bird. Medium size.	23	Forest trees.	Eating fruits.
6/6	Black and White waders. Very large.	42	Margin of fresh-water lake.	Searching mud with long beak.
9/6	Black crested Hawk. Large.	1	Open ranch land.	'Steeping' at ground object.

FIGURE 66. A chart for recording bird observations

It will be necessary to keep constant watch for wild mammals in the school garden, as they will be there seeking food. Observe the signs of damage done by the more common kinds. Investigate the various methods of trapping used locally; and in connexion with the larger mammals, revise the necessity for a good fence round the garden.

A more detailed study of the habits and behaviour of birds may be made than hitherto, particularly in relation to their feeding. Build up a chart showing the various kinds of garden birds and the food they have been seen to eat. Note which birds are definitely beneficial and should never be destroyed. Similarly, note those which are troublesome pests. For this purpose, classify birds as (i) non-flying birds, (ii) swimmers, (iii) waders, (iv) scratching birds, (v) climbers, (vi) flesh-eaters, (vii) scavengers, (viii) fruit-eaters, (ix) insect-eating birds, (x) honey-suckers, and (xi) seed-eaters.

Explain that such animals as frogs and toads consume many harmful insects in a garden, therefore they are beneficial and should be protected. Encourage children to check on these animals by their own observations, and to discover other animals which are useful for the same reason (e.g. the chameleon). Is there any observable fact which supports the commonly held belief that the chameleon is harmful?

Practical work

a. Construct some simple box traps which do not injure the animal, and try to capture small mammals or birds. If caught, they should be released after a short period of observation in a cage.

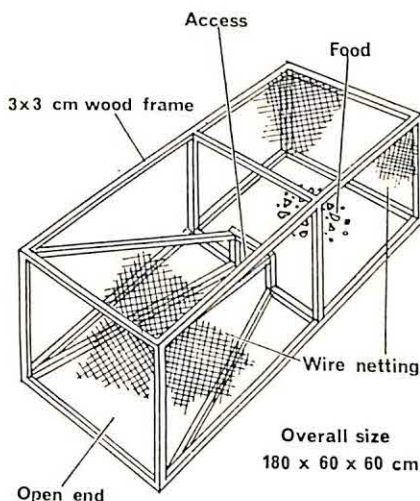


FIGURE 67. A trap for small birds

b. Continue to attract birds to the garden by making nest boxes, food tables and water troughs for them. These objects should all be sited in convenient places where the birds can be watched without, at the same time, disturbing them. Record visitors daily, noting their habits.

c. Birds which become a nuisance in a garden by damaging small plants, may be kept away from them by hanging strips of white cloth or brightly coloured discs of metal, such as old tin lids, over them. This method may be used to keep birds away from fruit trees and certain kinds of vegetables, such as peas. Alternatively, a network of fine cotton threads, supported on low posts, may be stretched over the plot. Which method is most effective?

d. Find a chameleon and keep it in a cage in the classroom for a few days under observation. Supply it with insects as food and observe its mode of feeding. Does a chameleon require water to drink? It should be remembered that there is no educational benefit to be obtained from animals kept in unsuitable conditions and without their needs being supplied.

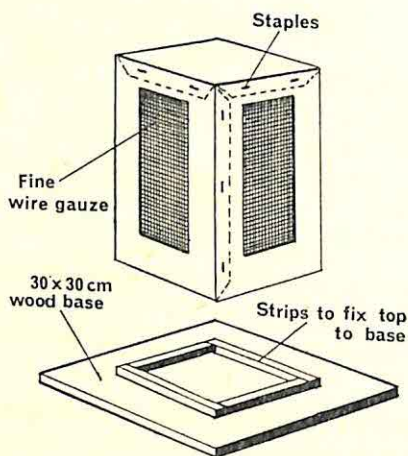
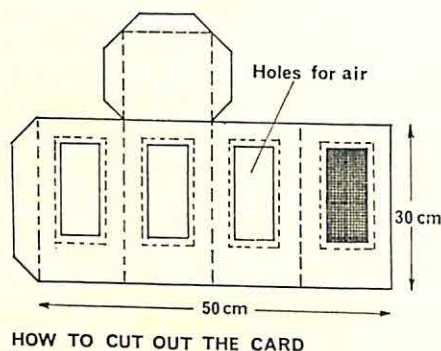


FIGURE 68. How to make a small cage

e. Continue with insect collections. As well as observing those which are pests, note the habits of useful insects, such as bees, the mantis, and dragonflies (if near water). What good do these insects do?

f. Do some more studies with other small animals, such as those found in the soil. Take samples of soil from various parts of the garden and spread them out on sheets of newspaper. Although insects and their grubs will be most common, millipedes may be seen;

and if the soil is from a moist, shady position near to water, mud-worms or earthworms may be present. Compare these two kinds of animals: note that whereas the millipede has a hard jointed body with

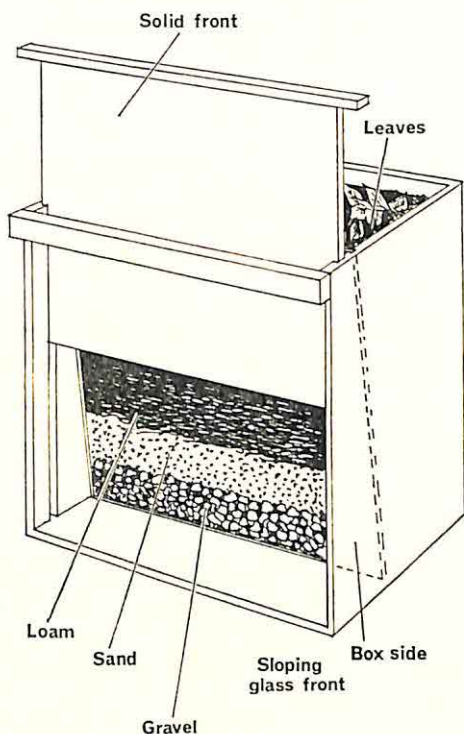


FIGURE 69. A design for a wormery

many legs, the earthworm has no hard outer covering to its body, and although its body is segmented, it has no legs. On what do these animals feed?

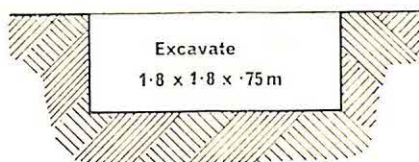
PROJECT WORK

Construction of a water-garden. Wherever there is water, birds, insects and other wild creatures will be found. To build a water-garden in a corner of the school grounds will be a project well worth undertaking, even if rather more ambitious than those proposed hitherto. It will incorporate many aspects of science and necessitate a number of different practical activities. When completed, it may be planted with water-lilies and other flowering plants, such as waterside rushes, reeds and grasses, as well as various kinds of non-flowering

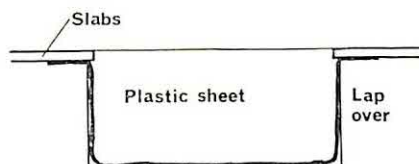
water plants and ferns. To indicate the wide scope of such a project, the main divisions of the work that would be involved are listed below, together with ideas for associated lesson work.

<i>Activity</i>	<i>Teaching material</i>
<i>Clearing the site and soil work</i>	Sub-soil and rock strata; drainage; tools: use of spade, wheelbarrow, pick, etc.; volume and cubic measurement; siting the pool as regards shade, sun, access, etc.
<i>Constructing the pool</i>	Materials: concrete, the function of cement in concrete, conditions for setting, laying concrete, smoothing the surface.
<i>The surroundings</i>	Laying paths; constructing flower-beds; preparation for planting; waterside plants.
<i>Filling the pool</i>	Water supply problems: piped water, surface water from a stream, hand filling; quantities measured in gallons; methods of emptying and refilling.
<i>Stocking the pool</i>	Types of plants to use; planting in baskets in water; fish; frogs and toads; water snails, etc.; animal visitors: birds, mammals, insects.
<i>After-care and maintenance</i>	Keeping the water clean; effect of sun and shade; animal and plant communities in the pool.

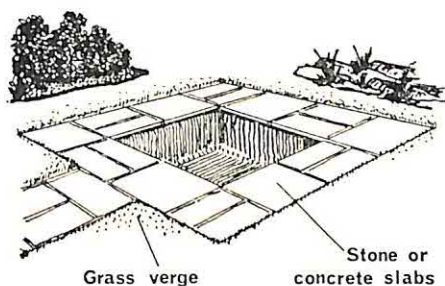
In certain places, of course, such a project would prove to be too expensive, or prohibitive on other account. An alternative to the use of concrete is to line the hole with some kind of plastic material, held down firmly at the edges. If a stream is situated conveniently close to the school garden, it may be possible to divert it and thus make the water available for a water-garden without the use of either concrete or any other bought material. One side of the stream may be merely widened to make a pool, and the bank supported by stones and turfs, and the roots of the waterside plants.



STAGE 1: DIGGING THE HOLE



STAGE 2: FIXING THE LINING



STAGE 3: COMPLETING THE SURROUND

FIGURE 70. A design for a garden pool

Material for the Fifth and Sixth Year Lessons

A. THE SOIL

Main ideas to be brought out

- (1) Soil consists of a fertile top-soil and a less fertile sub-soil.
- (2) Plants grow rooted in the soil, animals feed on plants, therefore most kinds of living things depend on the soil.
- (3) Soil is easily carried away, by rain water during wet weather, and by wind during the dry seasons.
- (4) Fertility is taken out of the top-soil by plants and animals.
- (5) The moisture content of the soil is continually being reduced; it evaporates, sinks into the sub-soil, and is absorbed by plants.
- (6) The soil may need to be terraced, drained or irrigated before cultivation can begin.
- (7) Soil must be dug properly and be well manured; the surface must be worked to a fine tilth.
- (8) A good tilth will be compact enough for the soil particles to be in contact with the root hairs or with the seeds; it will permit air to enter yet will hold moisture.
- (9) Tractors are used to draw farm implements; the plough is used to turn over the top-soil.
- (10) Harrows and cultivators are used to prepare a fine tilth for a seed-bed, and to loosen the soil during plant growth.
- (11) There are certain essential chemicals required by plants from the soil; soil chemicals are returned to the soil by using manures and fertilizers.
- (12) Fertilizers may be organic (from living things) or inorganic (formed from non-living substances).

(1) to (5): Erosion and soil conservation

It is often overlooked that the care of the soil is highly important, perhaps because it is not recognized as the raw material from which a farmer starts his work, and because it is generally so plentiful; the fact that it can be actually made is not realized. Also the process by which it is used up is slow enough not to be immediately obvious.

Such limitations contribute to the comparative ignorance of this aspect of a farmer's work. Soil care is in reality his most essential task, as all living things on the farm, including the farmer himself, depend on the soil.

To begin with, have a discussion lesson on this idea: that since all land animals, including humans, are dependent on green plants for their food, life is mainly dependent on the soil. Discuss the methods in use locally to protect the soil, particularly the customary ways of terracing the land. Are they effective? Do they involve a lot of labour? Show pupils pictures of terracing in tropical lands where it is done particularly well (e.g. Indonesia).

Revise the water cycle in nature and other related topics, such as the importance of the elements nitrogen and carbon to living things, and the origin of soil from rock. Consider how moisture and fertility are lost from the soil in areas where heavy crops are grown, or where much livestock produce is sold off the land. What is the percentage of water in milk?

At the end of this section, an essential overall conclusion to reach is that a balance must be maintained between the crop-growing capacity of the land and the number of livestock which it supports.

Practical work

a. Construct soil-profiles to introduce the idea of the difference between top-soil and sub-soil. Encourage the pupils to choose their own sites from which they will collect soil samples for this purpose (e.g. road cuttings or river banks).

b. Use a model to demonstrate the effect of seasonal rainfall on top-soil. What can be done to prevent surface-wash in newly ploughed fields and gardens? In a similar way, demonstrate wash on unprotected slopes, and the beneficial effect of barriers, or steps, built across gullies. (Figure 72.)

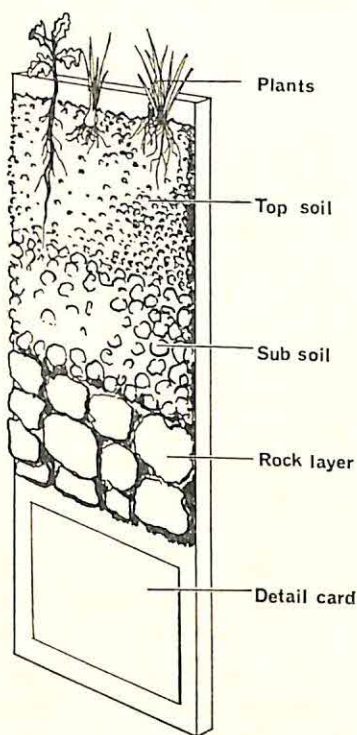


FIGURE 71. A model of a soil profile

c. If real erosion gullies are to be seen, pupils may mark the depth and width of them on sketches; and then compare them with measurements and sketches made later in the year, after the next heavy falls of rain.

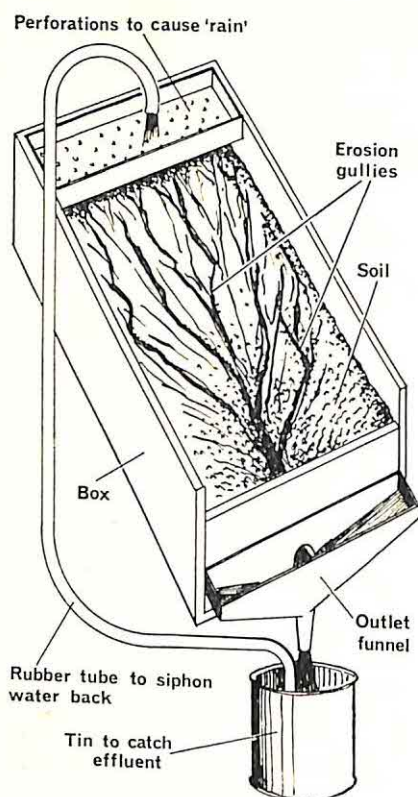
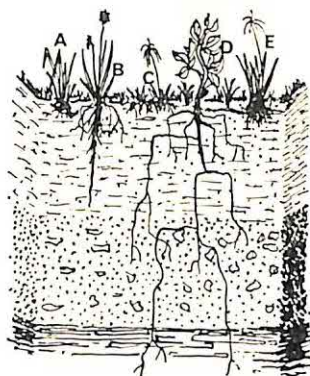


FIGURE 72. A model to demonstrate surface erosion

- d. Collect pictures from newspapers, magazines, etc., to illustrate damage done to the soil by wind erosion. Where in your country is such a form of erosion a danger? Consider ways of control. What are the most suitable kinds of trees for wind-breaks?
- e. Dig a large deep trench in a grass field, and observe how some plants send their roots deep down into the sub-soil. What kinds of plants are dependent on the top-soil entirely?
- f. Do some experimental planting of grasses used locally for binding the soil, such as along the banks between terraces. Are any plants other than grasses suitable for this purpose?
- g. Find out from agricultural authorities whether the domesticated

livestock population has increased or not in recent years. What are the reasons for changes that may have taken place in this respect? Point out to the children that although animal populations, like human ones, are generally increasing everywhere, the amount of land



PLANT	ROOT LENGTH	DESCRIPTION
A	8 cm	A corm
B	35 "	A taproot
C	10 "	Fibrous structure
D	90 "	Branching
E	14 "	A bulb

FIGURE 73. Recording facts about roots in the soil

available for agriculture is limited, and is even decreasing in many places, being used for towns and roads. What conclusion may be drawn from this fact?

(6) to (10): *Digging and soil cultivation*

The custom in tropical lands is never to dig the soil very deeply, merely to turn it over to a depth of about four inches. There is every reason to believe that in most parts, the soil would increase its productivity if deeper cultivation were practised. By comparing crops grown in properly cultivated soils with those grown in soil poorly prepared, the importance of tillage may be taught.

Whilst the technique of deep-digging is being demonstrated, the

reasons for it must be stressed. These are the need to permit air and water to reach lower levels of the soil, and to allow humus to be incorporated with the sub-soil, so that roots may penetrate more easily to greater depths, and there make use of reserves of fertility and moisture.

An essential preliminary to the preparation of the soil may be to terrace it. If the school garden is at all sloping, this work will need to be done when the garden is first built. Nevertheless, instruction in the principles of terracing may be included whilst comparing the results obtained in the locality by farmers who terrace their land, and by those who do not.

Discuss the effects of bad drainage on the soil structure, fertility and productivity. Teach the meaning of words such as sour, acid, water-logged, heavy, in connexion with the soil.

Consider the possible methods of bringing water to the school garden. What are the advantages and disadvantages of piped water, and water carried in an open furrow? Explain the use of the watering can and the sprinkler. Stress the dangers of over-watering, in that air is prevented from entering the soil, and that moulds are likely to form.

Most of the teaching related to the above will be done during the normal course of garden work. A farm visit may give the opportunity to teach some of the ideas related to the following aspects of soil cultivation.

On a farm, the most important implements concerned with the soil are the plough, the harrows, the cultivators, and the tractor which is used as a source of power to pull the other implements. These are objects of great interest to most young people; but unfortunately they cannot be dealt with practically in most schools, because of the absence of machinery on nearby farms. If an agricultural institute, or other large farm with implements is close at hand, it should, of course, be visited as already suggested; but a good 'second best' approach is to obtain pamphlets and other illustrated information from implement manufacturers, and use them as a basis of classroom lessons.

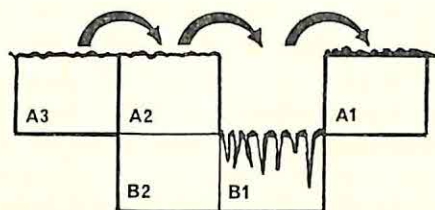
At this stage, it is more important that pupils should learn what machines are used on the farm, and how they are used, rather than try to understand in detail how they work. However, the general principles of the internal combustion engine may be taught, and this will be related to much basic science. When dealing with tractors, the smaller types with two wheels only should not be forgotten. Being man-handled from behind, they are often more suitable for the kind

of small-holding common throughout the tropics than the larger type of four-wheeled tractor. The advantage of the large driving wheels on tractors will need explanation; and also mention must be made of the fact that it is possible to alter the width between the wheels sometimes, to fit the rows of plants, when a tractor is being used to pull a cultivator.

A good approach to the study of the plough is to use the historical method. Teach that the earliest ploughs were simply branches of trees, selected because of their curved shape, which when pulled through the soil, cut a groove. The idea of actually turning over the soil came later: for this purpose, the ox plough had a mould board made of iron, and other parts were added, including the plough-share and the coulter which cut a clean edge to the furrow. Modern, tractor-drawn ploughs have more than one mould-board, and therefore are able to open up a number of furrows at each crossing of the field.

Practical work

a. Demonstrate deep-digging in the garden, involving the loosening of the sub-soil, and the mixing of compost with it. Show how the top-soil from the first trench must be kept aside to be returned later to fill in the final trench. Which is the best tool for the work?



Spit A1 is moved away. The underlying B1 is forked loose. A2 is then dug into the space above B1 permitting B2 to be forked loose in turn. A3 covers B2 and so on.

FIGURE 74. How to dig

b. Lift rooted plants and examine them for fibrous growth. Note how the soil clusters to the roots. Then use diagrams to explain how soil particles must be in contact with the roots of plants, if the crop is to survive; or with seeds if they are to germinate.

c. Soil moisture must be able to penetrate the soil. By comparing the roots of plants pulled from an area of swampy ground with those

taken from well-cultivated garden soil, demonstrate the effects of water-logging on root formation.

d. Air must be present in the soil. Show the effect of a 'pan' under the surface layer of the soil. What is the cause of this? How may it be avoided? Compare weed plants growing wild on (i) ground over which people are constantly walking (e.g. a path across a field); and (ii) on ground which has recently been dug up (e.g. a plot of ground left fallow after a previous crop).

e. If possible, visit an area of marshy ground, and note carefully the characteristics of the plants which grow there. What methods of drainage would be most suitable? If not too difficult, actually drain a small part of the marsh and observe the changing effects on the vegetation, in later school terms.

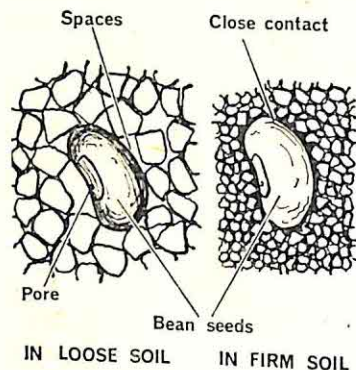


FIGURE 75. Seeds in the soil

f. Give practical instruction as to the correct time of the day to apply water, and the amounts required for particular kinds of plants.

g. The idea of the plough can be demonstrated by using models.

Begin by making a simple wooden model of a primitive plough. Then a mould-board plough can be attempted, using a strip of metal twisted into a curved shape for the mould-board itself, fixed to a piece of stiff wire. This will turn the soil like a real plough, if drawn through soft soil or sand. (Figure 76.)

(11) and (12): Manures and fertilizers

The idea behind the use of manures and fertilizers is that they are intended to replace the loss of chemical substances from the soil, and to provide moisture-holding material. The absence of moisture in the soil can be detected by observation of the plants growing in it. Similarly, those chemical salts which are deficient in the soil can also be ascertained from the appearance of the plants. Point out the features of plants lacking (i) nitrogen, (ii) phosphorus, (iii) potash and (iv) lime, and those suffering from too much of these chemical elements, whenever the occasion arises, and suitable plants are available.

Different kinds of manures may be classified as (i) compost, (ii)

farmyard manure, (iii) green manure, (iv) organic fertilizers, and (v) inorganic fertilizers (artificial manure).

Pupils will have been concerned with the making of compost for some years, of course; but at this stage, some idea of the processes upon which the making of good compost depends, may be revised in detail. Why is old compost useful to mix with the other substances in a compost heap? What is the purpose of adding water to compost? Teach the value of good compost as the end-product of decay. Point out that in some tropical lands, vegetable matter will not readily rot down on its own, in the soil, due to the generally high temperature

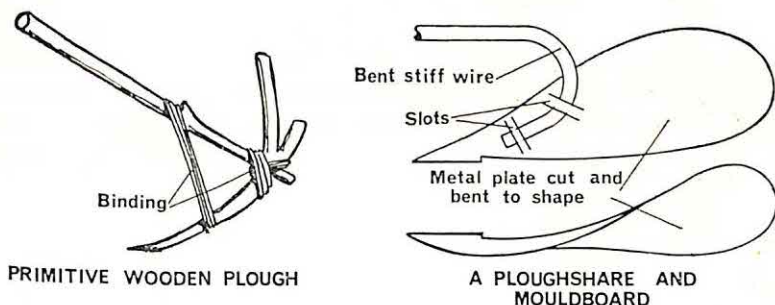


FIGURE 76. Model ploughs

and dry conditions, but that in the humid, densely forested regions of the tropics, the opposite is the case.

Distinguish between stable manure (horse, mule or donkey), cattle, pig and poultry manure. Give an indication of the required rates of using farmyard manure of these kinds. Discuss the use of green manure. At what season of the year should it be dug in? What plants are suitable for this purpose? What is the importance of including a leguminous plant in a green manure mixture?

Revise the meaning of 'organic matter', with reference to the following examples: hair, hoof-and-horn waste; dried blood; crushed bones; wood ash; sea-weed; all of which are used as fertilizers.

The idea of artificial fertilizers may be introduced by outlining the history of their development since they were first invented over a hundred years ago in Britain, when crushed bones, wood ash, and the chemical sulphate of ammonia were mixed together and applied to the land. Teach the limitations in these artificial fertilizers: they make good a chemical deficiency temporarily, but do nothing to replace loss of humus, and therefore do not help to maintain the

moisture content of the soil, which means plants are unable to make use of whatever fertility is present. It is possible to stress the harmful effects on the soil of the continual use of artificial fertilizers in lands such as North America and Australia, by showing pictures of erosion due to humus deficiency brought about in this way. Question pupils as to their knowledge of which fertilizers are recommended for use with the important crops of the district. Remind them that grass is the main farm crop generally, and discuss which artificials are beneficial to grassland. Mention 'trace elements' required by plants; and if possible, show pupils samples of copper sulphate (blue stone), magnesium sulphate (Epsom salts), and calcium sulphate (Gypsum), as examples of substances which can be used to keep up the supply of some of the trace elements in the soil.

Although not really a manure, calcium oxide (lime) is an important soil constituent. Teach its value both as regards the nutritive effect it has on plants, and its influence on the mechanical properties of soil and on the other soil minerals. Record which plants prefer a lime-free soil and those to which lime is essential.

Practical work

a. Shake up some soil containing much clay in water in a bottle. Notice how the clay particles remain in suspension for some considerable time afterwards. Now shake up a similar amount of clay

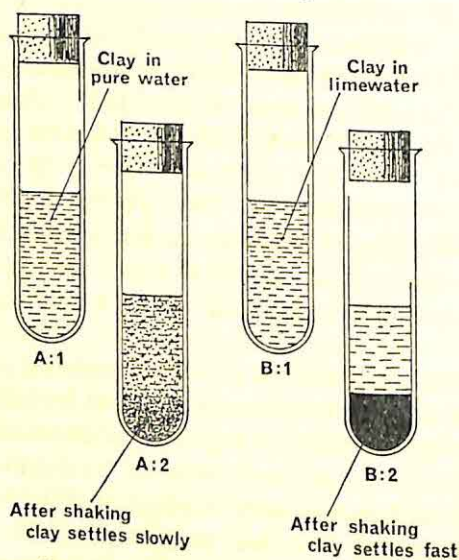


FIGURE 77. An experiment to show the effect of lime on clay particles in the soil

soil in lime-water and observe the effect on the clay particles. Do they settle more quickly than in the former case? What would be the effect of adding lime to the soil in a garden which is predominantly clay? If possible, observe the methods used by farmers to apply lime to their fields. From where is lime obtained?

b. On the demonstration plots, treat the soil with animal manure at different times of the year: during the resting season: during the growing season; and immediately before sowing or planting. In each case observe the rate at which the manure rots down into soil to completely disappear. As a result, decide on the most favourable time to apply manure in your area. What are the factors which cause manure to rot?

c. Dig up four small plots in the same part of the land where it has not been cultivated for some time. Leave the first untreated with fertilizer, top-dress the second with a fertilizer containing nitrogen,

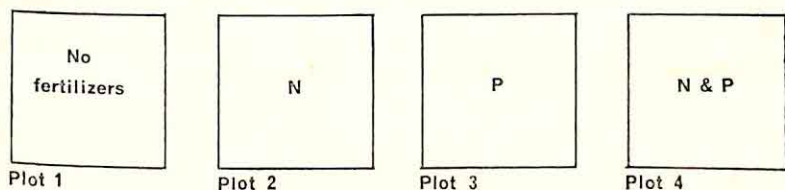


FIGURE 78. Investigating the effect of artificial manures on soil fertility

the third with a fertilizer containing phosphorus, and the fourth with both kinds of fertilizer. In each, sow an equal amount of grain, and cultivate each plot equally well subsequently. A comparison of the growth of the plants, and later, of the quantity of produce obtained from each plot, will provide information as to the fertility of the soil. For example, if a great amount of dark green leaf is produced, this will suggest too much nitrogen; whereas signs of phosphate deficiency are the leaves turning brown at the edges, a slowness of the plant to produce seeds, and weak roots.

d. Make a garden 'bonfire' burning woody material obtained from hedge clippings, tree prunings, etc. Keep the ash without letting it get wet, and later, top-dress half of a plot growing roots with it. Compare the results by measuring the yield of roots from each half of the plot separately. What mineral does wood ash particularly supply?

e. Certain chemical salts are harmful to plants. Put two leafy stems of a herbaceous plant in separate jars containing water, and to one add a spoonful of common salt. Observe the effect of the salt on the

leaves of the cutting by comparison. Alternatively, using two similar cuttings standing in water, add a few crystals of copper sulphate to the water in one jar; and spray the leaves of the other plant with a solution of copper sulphate dissolved in warm water, making sure in this case that none enters the water in which the plant is standing. Compare the results.

Assignment subjects

- (i) The evidence that living things are dependent on the soil.
- (ii) Soil depth and soil fertility.
- (iii) Local causes of soil erosion.
- (iv) Methods of soil conservation.
- (v) Farm implements for tilling the soil.
- (vi) Local sources of organic waste for manure.
- (vii) Methods of conserving animal manure.

The teacher is referred back to page 49 for notes on the preparation of assignment cards, and information on how to encourage pupils to learn by this individual method of study.

B. GARDEN PLANTS

Main ideas to be brought out

- (1) An annual plant produces seeds within one year and then dies.
- (2) Biennial plants take two seasons to come to seed; during the first season, food is made and stored in the leaves, roots or stems.
- (3) A perennial plant flowers each season for a number of years.
- (4) Herbaceous plants may be increased by cuttings, layers, and by replanting food storage organs.
- (5) Cuttings from a parent plant may be taken of hard or soft wood.
- (6) Some plants are propagated by division of the root stock.
- (7) Small shrubs and trees must be planted in the correct manner; there is a correct spacing for all trees and shrubs when planted.
- (8) Hedges should be planted properly, and then tended with care if they are to remain stock-proof.
- (9) The soil around shrubs and trees must be cultivated whilst the plants are young; it may require mulching and fertilizing.
- (10) Shrubs must be pruned when young to give them a good shape; some trees require pruning to make them bear fruit plentifully.

(1) to (3): The variety of garden plants to grow

A more detailed study of the plants which may be cultivated in a school garden is now included. This first section deals with the soft-stemmed plants, and the overall aim should be to acquaint the pupils with their wide variety of form and habits of growth. Which kinds may actually be planted in any particular place will depend on local conditions and cannot be detailed in this book. But herbaceous plants should find a place in every garden. They may be grouped in flower-beds in various ways: either according to botanical families; in a mixed fashion, with plants from various families and with differing habits or growth alongside each other; or in classes, as annuals, biennials or perennials. If desired, specimens belonging to this latter group can be planted in beds according to their habit of growth, i.e., beds of border plants, climbers, bulbous-rooted plants, succulents and cacti, etc.

Teachers should find out from seed firms and plant shops, from agricultural officers or from books on gardening, which herbaceous plants are likely to flourish in the area; they can also observe what plants grow well in private or public gardens. The only way to become familiar with the characteristics, needs and habits of these plants is through practice and close observation. It will be through the actual growing of herbaceous plants therefore that the principal ideas of this section can be learnt. The important thing is that teachers should experiment: be ready to try everything and observe the results. Even if land is limited, as mentioned before, many kinds of herbaceous plants can be successfully grown in boxes or tins and kept on the school terrace or verandah.

Practical work

a. Annual seeds may first be sown in seed-boxes or beds, or direct into plots in the garden. A good idea for some varieties is to spread the seeds of annuals amongst shrubs, permitting them to grow and multiply unrestricted. Although weeds may be a problem, these annuals will provide many flowers and much material for lesson work.

b. Although certain herbaceous plants are biennials they are not common in tropical flower gardens. Many plants which would take two growing seasons to reach the flowering stage in more temperate lands, adopt the annual habit here. One example to mention, however, is the wallflower (*Cheiranthus*) which has particularly sweet-scented four-petalled blooms. The habit of growth of biennials is,

however, more easily observed when cultivating vegetables belonging to the Brassica group (see page 110).

c. There are some families which contain many plants suitable to be cultivated alongside each other in the same bed. Examples are the legumes, composites, grasses, lilies and labiates. Arrange part of the school garden with this idea in mind. Which of these families are mainly herbaceous?

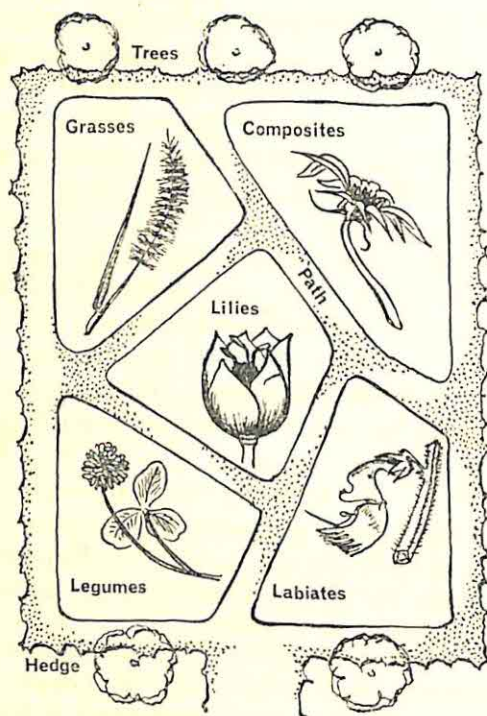


FIGURE 79. A layout of garden beds planted according to botanical families

d. Plant an area of ground with grass seeds of a low-growing variety, and make a lawn. The ground must be carefully levelled beforehand. All weeds must be permitted to germinate and then be pulled out by hand before the grass is sown. There will be certain tasks necessary afterwards in order to keep the lawn in good condition, such as cutting, trimming the edges, weeding, and filling in hollows with sandy soil, or even rolling.

e. Many kinds of succulent plants and cacti grow in tropical countries; and in the absence of cultivated flowers the special forms of

these plants may be studied as a result of collecting wild varieties and planting them in a garden plot amongst rocks, similar to their natural habitation. Care must be taken to see that children avoid the stinging hairs, spines, etc. Why do these plants particularly need the protection of spines, etc?

f. Construct some wire frames over which climbing plants may spread themselves. Similarly, plant trailing species on the top of banks or walls, and permit them to spread downwards. Compare the methods of climbing and trailing (e.g., use of suckers, tendrils, etc.).

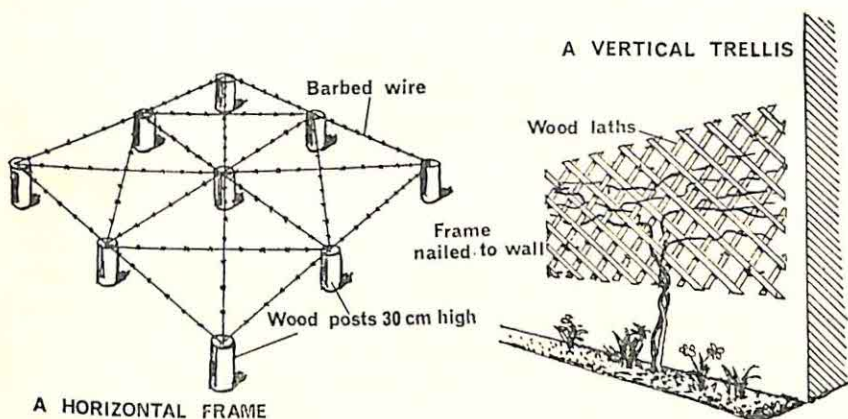


FIGURE 80. Frames for climbing plants

g. Make cages or baskets of wire which can be hung from an overhead beam in the shade of a building. Put moss, rich leaf-mould and soil in them, and plant wild ferns if they can be obtained in the school locality (see Figure 3).

h. Make boxes about a foot square and nine inches deep, with holes in the bottom to permit drainage. Fill with rich soil and plant scented specimens of shrubby plants, such as honeysuckle, lavender or *Carissa*. Alternatively, plant them in tins of about the same size (e.g. kerosine tins cut in half) which have had holes punched through the base. Keep them in positions where the blooms can be enjoyed by everyone.

i. If the school is situated in a suitable place, try the cultivation of various kinds of plants which are found growing on the branches of trees, e.g., ferns, orchids, mistletoe (*Rhipsalis* and *Viscum*), or *Loranthus*. How do these plants get their food and water naturally?

(4) to (6): *Vegetative propagation*

The most common methods of propagation using the parts of plants other than the seeds, are (i) taking various kinds of cuttings (ii) taking layers; (iii) division of the root stock; and (iv) by replanting suckers. In addition, there are special methods peculiar to certain plants only, such as leaf cuttings. Budding and grafting are other specialized methods for woody plants which are rather too difficult for pupils at this stage.

Propagation should be tried at different seasons of the year, and in different kinds of soil. In this way, a wide knowledge of such garden tasks may be acquired, especially if careful records are kept. The success or otherwise of increasing plants artificially depends mainly on the presence of conditions favourable to growth. These are an adequate amount of moisture in the soil, a suitably humid atmosphere (generally achieved in the garden by providing shade), a suitable rooting medium (which may not be rich soil, necessarily), and the correct soil temperature.

It is important to have plants ready by the time they are required to fill the beds. This is usually at the start of the rainy season; and it will be necessary, therefore, to propagate well in advance. Experience will indicate the time needed in each case.

Practical work

a. Break, or cut off pieces of branches from shrubs, such as *Hibiscus*, making sure that they have a 'heel' (part of an older branch). Trim off the leaves, and put such hard-wood cuttings at an angle in the soil

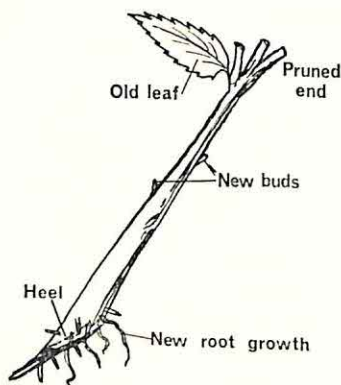


FIGURE 81. Taking a hard-wood cutting

in a shady position to root. Keep the soil moist and do not move until the following season. From time to time, single specimens of such cuttings may be lifted to observe the development of the roots, and drawings made of them.

b. The branches of some climbing plants, such as *Jasmine*, bend down to the ground and root at the 'nodes' where they touch the soil, which is a natural means of vegetative reproduction. The section of the plant around the rooted node may be cut off and replanted.

c. Experiment with layers using a *Bougainvillea* plant. Bend a branch to the ground and make a cut on the underside at the point where it touches the soil. Peg it down with a forked stake, and cover with rich soil and shade-giving material to keep it moist. In course of time,

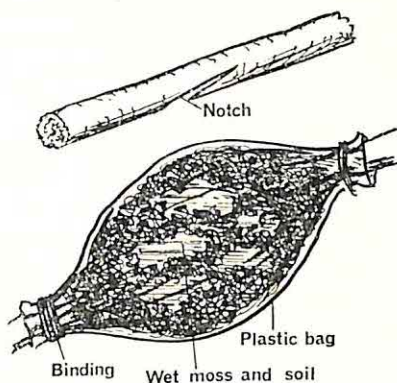


FIGURE 82. A method of causing a stem to form roots

roots will form and the section of stem may be cut off to form a new plant as in (b). As an alternative, enclose a stem section in a 'parcel' in which is moist soil and moss, as shown in Figure 82. Water can be fed to the parcel by means of a cord leading from a section of

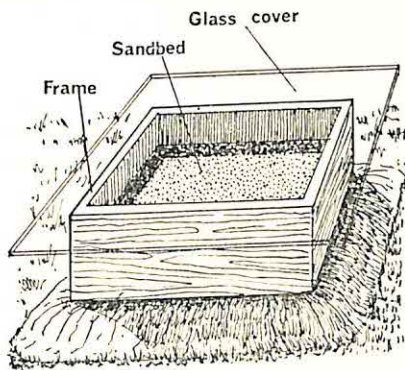


FIGURE 83. A cold frame for soft-wood cuttings

bamboo hung above it. The cut stem, moss and soil can also be kept moist if they are all enclosed in a plastic bag tied tightly at each end. d. Put a variety of soft-wood cuttings in water in jars and observe the roots forming on some of them. Are root hairs to be seen? Will they continue to grow if now planted in soil?

e. Prepare a bed of clean washed sand, about a metre square and approximately twenty centimetres deep, on a foundation of well-drained ground. Construct a wooden frame, $60 \times 60 \times 15$ cm deep, with no bottom, and place it firmly on the sand bed. Plant some soft-wood cuttings in this 'cold frame'. Place a piece of glass over the top, but care must be taken to see that the air is permitted to enter for ventilation, to avoid moulds forming. (Figure 83.)

f. Break off a piece of a Cactus plant and allow the wound to dry before it is put in the soil to grow again. Alongside, plant another piece for comparison, immediately it has been taken from the parent plant.

g. Take leaves from succulent plants, such as *Crassula* or *Bryophyllum*, and rest them flat on a soil surface, held in place, if necessary, by a small stone as a weight. Observe the growth of rootlets, and later, of shoots round the edges of the leaves.

h. Dig up the roots of a Lily or *Amaryllis* plant, in the resting season, and note the formation of young bulbs around the original one. If *Gladioli* plants are available, remove from the soil and note the formation of new corms. Replant these parts after separating them from the parent plant. Draw sections of bulbs and corms for comparison. From what parts of the plant have they been formed?

i. Lift the root-stock of an herbaceous plant, such as *Gerbera*, and split it up into as many parts as possible. Replant each part separately, and water regularly until they are established again.

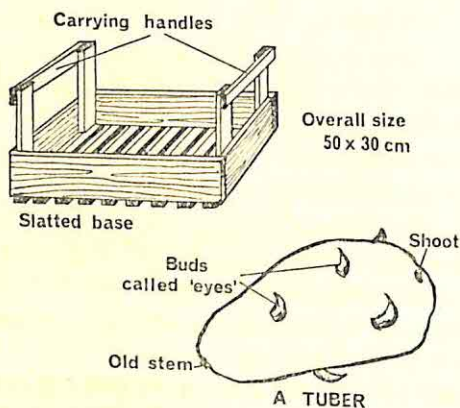


FIGURE 84. A design for a chitting-box

j. Make some 'chitting boxes' for seed potatoes. Keep a selection of potato tubers in the boxes in a shaded open position, in order to

observe the sprouting shoots on these swollen underground stems. Later, plant out the prepared 'seed' alongside other tubers not sprouted in this manner. Compare rates of growth and development.

(7) to (10): *Caring for trees and shrubs*

Trees and shrubs are similar to herbaceous plants in that they require planting properly, and satisfactory after-care, although it is true that once the larger kinds have become well-established, they can be left alone almost entirely. Whilst they are young, however, there will be many important tasks to remember, such as mulching the soil around them, protecting them from competitive weeds, and pruning the branches. In this latter respect, local methods may be compared with advice obtained from agricultural authorities. It may be noted that the general purpose of pruning is to help the plant form a good shape, permit light and air to enter into the centre of it, and in some cases, to help fruit to form, at regular intervals of time, which is of a satisfactory size. Indicate special methods of pruning, such as are used for tea, coffee or rose bushes. As regards those trees and shrubs used for hedging purposes, they will require trimming to keep them reasonably low and impenetrable.

Classroom instruction may introduce the practical work which will be the best way of dealing with this section. Use diagrams to teach the most satisfactory methods, and to stress the purpose of each process.

Practical work

- a. Demonstrate how to plant a small tree. Why do the roots need to be spread out in the hole? Indicate the depth and size of the hole to suit the plant, and the depth at which the tree should be standing in it. Show how to stake the tree after planting and protect it from damage by building a post and wire cage around it.
- b. Young plants need mulching and shading after planting. What are the most suitable materials for this purpose? Mulch and shade most of the trees planted and compare with a few left without such protection.
- c. What is the value of using different kinds of plants to make a boundary hedge to a school garden? Demonstrate the correct spacing of hedge plants to secure a stock-proof boundary. Compare the advantages and disadvantages of single and double hedge planting.
- d. Plant some trees on the windward side of the demonstration plots. In years to come, these will act as a wind-break. Leave a short strip

not planted so that eventually the effect of the trees on the vegetable plants growing in their shade may be compared with those not protected in this way. Do the roots of the trees have any detrimental effect on the garden soil?

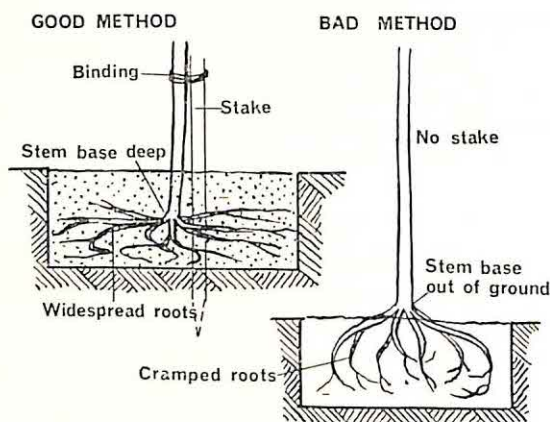


FIGURE 85. How to plant a tree

e. If none are in existence already, plant some shade trees in suitable positions, where future pupils of the school may obtain protection from the sun during their rest time. Note the form of the trees which give the best shade.

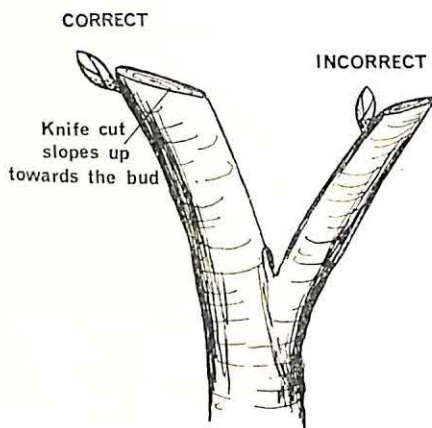


FIGURE 86. How to prune

f. Demonstrate the trimming of hedge plants. Use a sharp knife for hard-stemmed plants; but show that even a strong stick is adequate

for hedge plants with soft stems and branches. Emphasize that to twine the stems of hedge plants together is not a satisfactory method, but that a hedge may be 'laid' to make it stock-proof (by partly cutting the main stems at ground level, and bending them over to lie along the length of the hedge).

g. Demonstrate the use of the secateurs for pruning small branches. Why is it advisable to paint over the cut end of the branches after pruning them? Where should a cut be made on a branch in relation to buds? In a similar manner, demonstrate the use of the saw for clearing out dead wood or unwanted branches.

Assignment subjects

- (i) Herbaceous plants chosen for colour, scent and leaf formation.
- (ii) Decorative grasses: colour and shape of leaves and flower-heads.
- (iii) The variety of bulbous-rooted perennials.
- (iv) Succulents and cacti: adaptation to environment.
- (v) Methods of climbing or rambling utilized by plants.
- (vi) Plant associations: parasites etc.
- (vii) Ferns and other non-flowering plants.
- (viii) Techniques of plant propagation.
- (ix) Trees and shrubs with decorative flowers, fruit and foliage.
- (x) Useful timber trees.

C. FOOD PLANTS

Main ideas to be brought out

- (1) Edible fruit plants may be trees, shrubs or herbs; many kinds have been in cultivation for a long time.
- (2) Fruits may be classified as either tropical, sub-tropical or temperate, according to the place of origin.
- (3) Fruits may be grouped according to their structure as either dry fruits (e.g. nuts) or succulent fruits (e.g. berries).
- (4) Any part of a plant may be attacked by a disease organism.
- (5) Many plant diseases are caused by moulds and other fungi.
- (6) Fungicides are chemicals used to kill fungus organisms on plants.
- (7) Other plant diseases are caused by microscopic organisms such as bacteria and viruses.
- (8) The most serious pests of plants are insects; particularly the larvae of insects.

- (9) Insecticides are poisons used to destroy insect pests; great care must be taken in using them.
- (10) Hand picking is an effective method of insect pest control.

(1) to (3): Different kinds of fruit crop

Although it is known that a fruit is usually something 'good to eat', it is not always clear to the pupils just which part of the plant it is that has ripened and become tasty. This can be the first approach to the study of edible fruits. It is usually those particular kinds of succulent juicy fruits, which are first thought of from a gardening point of view: berries like the tomato, grape, orange or banana. It should not be forgotten, however, that the coconut is a fruit, also the grain of a cereal and the pod of a bean.

These examples are all true fruits formed from the seed-case of the plant, but there are some edible flower parts, generally considered as fruits, which are really due to the swelling of some other part of the flower. Examples are the pineapple, in which the whole of the flower-head becomes juicy, and the fig, which is mainly a swollen flower stalk. It is necessary for teachers to examine fruits closely, and try to decide just how they are formed.

All pupils should have the experience of seeing edible fruit trees growing. Although a wide range may be attempted, only one or two specimens of each are necessary. Certain types of fruit plants, however, such as citrus or banana, grow best when planted in a block, making an orchard, a small example of which a school may wish to include. This should always be sited carefully in relation to the prevailing wind, and fenced around to give protection from pests and thieves.

Plants of tropical origin will be mainly grown, but an aim will be to make known the various kinds of fruits with which pupils are not familiar at first hand. This may be done by means of a teacher's collection of pictures showing both temperate fruits, such as the apple or plum, and sub-tropical fruits, like the grape and the olive.

Practical work

- a. Examine a local fruit and discuss which parts are fleshy and juicy and therefore edible. Has the fruit formed from one or more carpels? Has any part other than the carpel swollen to form the fruit? The pomegranate, passion-flower, loquat, mango, and jak-fruit are good examples to observe, if available.
- b. Find the seeds in a selection of juicy fruits. Make drawings of the

fruits in cross section and also of the individual seeds. Have any of the fruits only one seed? Suitable examples are the custard-apple, guava, avocado-pear, water melon, and pawpaw.

c. Make diagrams in order to understand the structure of a nut. Break open a ground-nut, Brazil nut or coconut, for example, and observe the formation of woody material around the seed. In what particular ways does a nut differ from juicy fruits? In what form is the food in these nuts usually found?

d. Make a detailed study of the banana. Obtain local information about the wide variety of these fruits in cultivation. Compare the male and the female flowers on a banana plant. How is the plant pollinated? Do seeds form in the fruit? What food substances does the fruit contain?

e. Examine a pineapple. Where are the flowers? Cut the plant down the centre vertically in order to discover which part has become juicy. If possible, visit a factory where these fruits are processed. How are they marketed commercially? By what means are they propagated?

f. Grow some water-melons or other 'gourds' by cultivating the vines from seed. Ask children to bring examples to illustrate the great variety of shapes which are possible in the fruit of these plants. What is the advantage of covering the fruit whilst it is ripening? How is the woody case of a gourd preserved?

g. Demonstrate the extraction of 'papaïne' from the fruit of the pawpaw plant. Explain its value commercially. Why is more than one plant generally necessary if the plant is required to bear fruit? Compare the flower, fruit, and leaves of a pawpaw with those of a passion-fruit. What similarities are there and why should there be any?

h. Test the scent of fruit plants such as citrus or mango. What is the cause of the aroma? Is the scent found in any other parts of these plants besides the fruit? Make drawings of the flowers of these plants.

i. Make a study of wild fruits of all kinds known to be good to eat. Collect the leaves, flowers and fruit and make drawings of them. As an alternative, the leaves may be pressed to form a more permanent collection, alongside of which may be pasted diagrams of the floral parts and fruit. Sow the seeds of these plants in boxes and attempt to start a 'wild fruit garden' in a corner of the school grounds.

(4) to (7): Diseases of garden plants

First have a discussion on the causes of plant diseases. Revise the life history of a fungus, stressing particularly the important fact

that as these plants are not green, they are unable to manufacture their own food. For this reason many plant diseases are due to fungus infection: the spores frequently alight on the leaves and stems of garden plants from which they are then able to obtain the nutrients they need. The result is a weakening of the host plant.

With the aid of good blackboard diagrams, the structure of a unicellular organism may be taught simply. Point out that although these forms of life are too small for our eyes to see them, we can observe some of the results of their living processes. It is possible to use the organisms known as 'yeast' for this purpose, a sample being obtained from the local grocery store or bakery. Yeast lives naturally in numerous habitats, but particularly on the surface of anything 'sugary', such as the skin of fruits.

Refer to the chemicals in poison sprays which kill the disease organisms in plants, and warn the children about the dangers of their use. Describe a typical fungicide (Bordeaux mixture, for example) and accentuate the fact that such sprays generally contain copper.

Bacteria are important organisms which cause disease, but are even more minute than yeast. The scum on the surface of a pool of stagnant water may be due to the presence of many millions of individual bacteria.

Practical work

- a. Examine plants in the garden which have diseased leaves (e.g. plants infected by 'blight'). Discuss possible causes, such as lack of soil nutrients, influence of microscopic life forms, etc. Are all the plants affected?
- b. Collect tubers of potato or other plant, affected by bacteria, causing them to become soft and discoloured. Compare the symptoms with those caused by blight (a fungus disease). How is each to be identified?
- c. Examine actual specimens of fungus infections and moulds cultivated in the classroom. Look for the spore-bearing parts through hand lenses. Name and learn to recognize common types which infect plants, such as 'rust', 'downy mildew', 'damping off', 'club-root' and 'sooty mould'. What plants do these infect? (Figure 87.)
- d. Demonstrate how yeast causes fermentation. Place a small amount of yeast in a sugar solution in a test tube, another in a paste made of starch and water, and a third in pure water. Cork, and leave to stand for a few hours. The tube containing yeast in syrup will fill with a gas which can be tested with lime-water to prove that it is carbon dioxide.

The liquid left in the tube has a strong smell of 'wine', due to the presence of alcohol. This is the process called fermentation. Why is there no change in the other tubes?

e. Observe 'wilt disease' on various plants and refer again to bacteria as the cause. Similarly, find examples of diseases caused by a virus, such as potato leaf-roll, leaf-mottling on beans, and tobacco mosaic. (Assistance as regards identification may be obtained from the local agricultural authorities.)

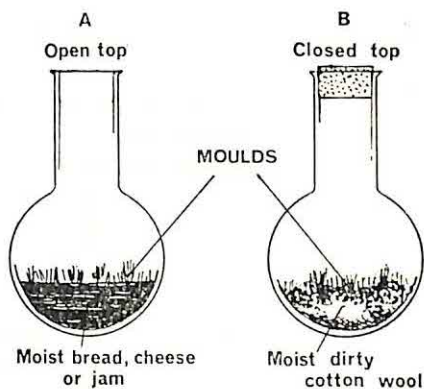


FIGURE 87. Cultivating moulds

f. Practise good habits of garden hygiene all the time. For example, encourage pupils to clear all decaying vegetable matter from the plots, after any crop has been harvested; compost continually; keep the soil well hoed, drawn up around the roots of plants, and free from weeds. Healthy seed should always be used, and similarly, sound and strong propagating material.

(8) to (10): Control of insect pests

This section is a continuation of work begun earlier. The particular insects to study at this stage are those kinds which are pests of farm and garden plants and animals, as a preparation for further work on how to control them.

Build up a table based on observation, showing the relationship between certain insects and the plant, or plant parts, on which they live. Harmful insects may now be classified as (i) ants, which often attend other insects like mealy-bug or scale, which themselves suck sap; (ii) aphids, sucking the juices of plants such as cotton, roses, beans and citrus fruit; (iii) bugs of many kinds, affecting the stems of shrubby plants such as coffee; (iv) beetles, chewing the flower petals,

leaves, seeds and roots; (v) caterpillars, cut-worms, cock-chafers and other larvae, chewing the stems, roots and leaves of plants; (vi) flies, attacking fruits, including beans, cucurbits and citrus; (vii) locusts and grasshoppers, eating grass and cereals, including rice; (viii) leaf-miners, burrowing into leaves of plants such as coffee; (ix) moths, some of which lay their eggs on the stems of fruit trees, or inside the stems of maize; (x) scale-insects, common on the leaves and stems of many shrubs and herbs, sucking the sap; (xi) termites, consuming the woody parts of old trees, and destroying the cellular structure of green plants like sugar cane; (xii) weevils, pests of grain crops, bananas and sisal.

Explain about insecticides, referring particularly to those of vegetable origin, such as pyrethrum. Mention, also, the use of a mixture of soap and kerosine as a suitable insecticide; but stress that the excessive use of chemicals has a poisonous effect on all living things, and the greatest care should always be taken when powerful insecticides are used.

Practical work

a. Observe the different kinds of insects common in the garden. Try to discover what are their natural predators. How do the insects obtain their food? What are their methods of reproduction? Refer to the idea of 'food links' in this respect.

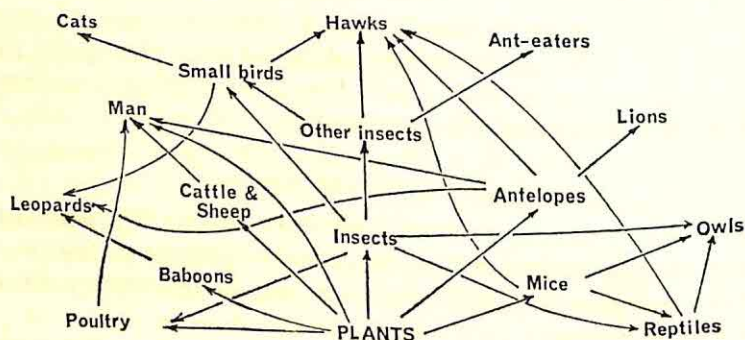


FIGURE 88. Some food links

- b. Insects which are serious pests should never be allowed to remain untreated for long, or to multiply at such a rate that the whole of a crop becomes infected. Experiment with insecticides. Are the plants affected by them?
- c. Some plants may be protected satisfactorily by picking the insects

off by hand. Make this a routine task by giving groups of pupils particular areas of the garden to protect in this way, for short periods at a time. Pupils should keep records of the type of insect pest with which they deal.

d. Take note of useful insects visiting the garden. Record separately, those that consume harmful insects, and those which help pollination. Which kind of insect is most numerous? Are useful insects more numerous than harmful kinds?

e. Take positive action to protect the woodwork of buildings against termites. To start with, always use suitable varieties of timber; protect the base of timber which is to go into the ground by means of oil, charring with fire, or other method used locally before construction. Dig out 'queen' termites and destroy them.

Assignment subjects

- (i) A comparative study of 'fruit structure'.
- (ii) Methods of seed dispersal related to fruit formation.
- (iii) Edible fruit plants.
- (iv) Detailed study of a selected fruit plant.
- (v) The fungus life-cycle.
- (vi) Living organisms and the rotting process.
- (vii) Insect feeding habits.
- (viii) Insect and plant associations.

D. FARMS AND FARMING

Main ideas to be brought out

- (1) On an efficient farm, problems of farm management are tackled scientifically.
- (2) Farms can be managed in a number of ways; how a farmer is able to use his land depends partly on geographical factors.
- (3) It is necessary to put ideas to the test before adopting them extensively on a farm; this may necessitate trial plots, etc.
- (4) The first essential of good husbandry is careful planning; a plan depends on a preliminary survey.
- (5) Records should be kept of all important aspects of management, to show which activities are financially worth-while.
- (6) Accurate accounts must be kept of all money transactions on a farm; costings must be made of chief activities.
- (7) Farm produce may be sold off the farm either on local

markets; through co-operatives; or by means of marketing boards.

- (8) Agricultural products form the main exports of most tropical lands, and farming is generally the main industry.
- (9) As most tropical lands do not have the necessary raw materials, agricultural machinery and equipment have to be imported.
- (10) The methods of using land for agriculture are changing, as more farmers produce goods for sale, and as more land is enclosed.
- (11) Agriculture is related to the population of a country; populations are everywhere increasing, therefore farm productivity must also increase.
- (12) Rural land is used for purposes other than agriculture; these include afforestation, water conservation, and National Parks for wild life.

(1) to (3): Farm management

At the very beginning of Part One of this book it was indicated that the scientific attitude must extend to all aspects of human life, if progress is to be made; it will be appreciated, therefore, that this includes the economics of land use. The manner in which agricultural land in any country is managed is thus as important a topic in rural science as any other. Pupils in their later years at school, particularly in countries where some are still obliged to end their schooling after the primary years, will benefit if they are acquainted with ways in which a farmer's work can be managed as scientifically as possible.

Farms are generally managed in one of three ways: either as a family unit; as an estate, with many employed persons working it; or as a co-operative enterprise, which may be complete in all respects, or only from the point of view of sharing equipment and marketing produce. Some idea of the advantages and disadvantages of each of these systems may be taught comparatively; and the topic will be made more interesting if it is introduced historically. Teachers should interest themselves in the development of agriculture and some facts were noted on page 11.

Decisions made on a farm with a view to planning a scheme of land utilization will always be related to the geographical factors of the environment, such as climate, landscape features, and altitude. A consideration of such factors can take place out-of-doors, and an attempt made to evaluate aspect in relation to site on a selected farm

or garden plot. Pupils may be set problems to solve such as, 'Where is the shade from afternoon sun greatest?', 'From which direction is the prevailing wind coming?', 'Has any part of the land shade from both wind and afternoon sun?', and 'In what direction is the land sloping?' (Figure 50.)

A fundamental principle of science is that ideas are put to the test; and many farmers experiment before deciding to grow any crops, or keep any kind of livestock on a large scale. An important activity in school rural science, at each stage, has been to experiment in the garden; but an understanding is now required of the wider process of experimentation which takes place in the farming industry. Obtain facts about agricultural research in the country from the authorities concerned, statistic reports, agricultural press, etc., to use as lesson material. Make use of simple methods of representing facts and figures diagrammatically in order to maintain interest, and make the information more meaningful. Whenever possible agricultural research stations might be visited by teachers, and information obtained about the work that is being done there, to be used in future class discussions.

Practical work

- a. Using pictures cut out of magazines, build up class wall charts comparing (i) family farms, (ii) large estates, and (iii) co-operative farming systems.
- b. Build models of various local natural features out-of-doors, as imaginative settings for farm sites. Pupils will then write descriptive accounts of the factors which would limit agricultural activities in the selected situations. (N.B. It is essential to indicate on the models the position of the north point, and the direction of the prevailing wind.)
- c. The effect of altitude on agriculture should be studied practically, if possible, by observing the variety of plants which grow naturally in any particular altitude zone. Collections can be made the basis of assignment work in this connexion.
- d. Observe the experiments in the trial plots being carried out in the garden by the pupils in lower classes. What is being attempted? What is being done to provide a 'control' for any of the experiments?

(4) to (9): Farm planning

Every farmer should have a plan of his farm drawn on paper. It will be useful not only as being part of the documents he holds in proof

milk yields over a period of time. Record them in the form of a graph. Compare a high-yielding animal with a poor one, and consider the seasons of the year in relation to the lactation of each (see page 47).

c. In connexion with some of the crops grown on individual plots in the school garden, simple costings may be worked out. The cost of the seed and fertilizer and other expenses should be shown balanced against the income obtained from the produce. Similarly, with small livestock, cost of food, etc., may be shown offset against the money obtained for the stock when sold.

d. Refer to simple book-keeping methods as taught in arithmetic; and

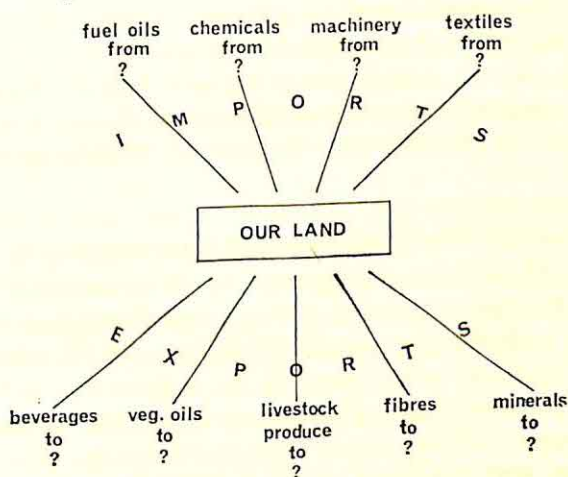


FIGURE 90. A country's exports and imports

indicate that on a farm, more elaborate methods are seldom necessary, but they must be kept up conscientiously. What is the purpose of an annual 'profit and loss' account made out by a farmer? What is the importance of a 'balance sheet'?

e. Arrange to visit local co-operatives and markets, so as to find out what happens to produce after it leaves the farms. Who owns a co-operative? What is the function of a national co-operative in a country's marketing system?

f. Draw block-diagrams to compare the amounts of the main exports from the country, and discuss where each is sent, and what is received in return. (Figure 90.)

(10) to (12): Rural land use

As there are great changes taking place concerning the use of the land in many tropical countries, pupils when they leave school ought

to have an understanding of what is happening, and why. The old custom of farming for subsistence is giving way to methods related to an economy based on monetary exchange: this is the chief fact to appreciate. But as populations are rapidly increasing all over the world, in order to feed the people, there is an urgent need for agricultural productivity to be everywhere at a maximum: therefore all concerned must endeavour to apply scientifically approved methods of land use in every way possible.

Because it deals with living things in the environment, discuss first the idea of 'balance in nature'. Does it exist? Investigate examples of competition in nature, such as that between many of the insects and the mammals. Is there evidence of co-operation in nature? Introduce the idea of 'mutual aid'. Compare with the struggle for survival in the wild. The question 'Why are wild animals seldom in poor condition?' will lead on to the topic of 'Wild animals as land protectors'.

Debate seriously the place of man in nature. Concentrate on the idea that man differs from other forms of life in that only he attempts to control and create his environment. To do this successfully, man must learn to study nature and *apply* the knowledge he acquires.

Consider agriculture as controlled interference with nature. Refer to specific examples of this, such as the manner in which natural forest may be maintained as a permanent tea or coffee plantation, an area of swamp land may be put to good use as a rice plantation, or poor 'scrub' land converted to productive pasture by the use of careful paddocking, construction of water holes, and livestock management in general. Note also examples of reckless interference by man with the natural conditions of his surroundings such as when a herd of goats are allowed to breed unrestricted until the number of animals is so great that the whole landscape becomes denuded of vegetation.

The important position of forestry in the environment, and the value of trees in maintaining balanced conditions, is an essential aspect of rural land use. Compare areas denuded of trees with areas recently replanted. Pupils may record on a map of the district areas where trees have been felled in recent times, and areas where woodland has been established. Why are conifers from temperate lands so often planted in new forests?

Discuss some of the particular relationships man has with wild animals. Is there any longer justification for hunting as a traditional way of life? The idea of human beings 'cropping' wild animals, as they

do their domesticated stock, can be introduced as an alternative to hunting which has been developed in recent years.

All aspects of this topic are dealt with more suitably by means of assignments than by the more usual kind of practical exercises, and there is a wide variety of topics that might be chosen for pupils to investigate in this way.

Assignment subjects

- (i) The effect on subsistence farming of the introduction of cash crops.
- (ii) Improvement in farm productivity as a result of enclosing the land.
- (iii) Populations and land use.
- (iv) Mutual aid and the balance of nature amongst wild life.
- (v) Agriculture and the conservation of natural resources.
- (vi) Altitude and plant growth.
- (vii) Forests and geographical features.
- (viii) Rainfall: its conservation and use.
- (ix) Local use of river water, and its storage in lakes, dams, etc.
- (x) Wild animal life and the function of National Parks.

E. FARM CROPS

Main ideas to be brought out

- (1) Certain crops are grown on farms, the produce from which is to be sold—these are called cash crops.
- (2) Some cash crops are herbs; these include medicinal plants, tobacco, dyes, oils and spices, fibre crops, cereals and sugar cane.
- (3) Certain cash crops are shrubs and trees; these include rubber, the beverage crops, fruits, and bark extracts.
- (4) Plants grown on farms specially to be fed to livestock are called fodder crops.
- (5) Certain fodder crops may be included in the rotation; others are better grown on plots separately.
- (6) Fodder crops may be dry fibrous food plants; plants with a high moisture content; or concentrated foods containing a high percentage of starch or protein.
- (7) Grass may be stored for use as fodder, either in the form of hay (dry) or as silage (succulent).

- (8) On large farms, special machinery is used for hay and silage making.
- (9) Rations are fed to livestock for maintenance and production; production rations usually consist mainly of concentrates.
- (10) Animals may graze their food freely in paddocks, or whilst tethered.
- (11) Animals may be stall fed in buildings; this method is most usual for feeding production rations of concentrates.
- (12) All livestock require adequate water for drinking, and the necessary minerals.

(1) to (3): Crops for sale off the farm

This topic was referred to in the first chapter in Part Two, and some examples of the so-called 'cash crops' may be growing already in the school garden. Pupils will also have acquired some knowledge of the crops grown locally for cash, and the methods of cultivation peculiar to them. The aim now is to give a wider knowledge of the variety of such crops grown in tropical lands, and the important place they hold in the economy of these countries.

The approach may best be made through classification, based on what the plant or plant part is used for. Although both vegetables and fruits might be cultivated extensively as a source of cash income to a farmer, it is other kinds of plants which will be considered here. The main groups are (i) spices, (ii) beverages, (iii) medicinal plants and plants for chewing, etc., (iv) oils, (v) gums and resins, (vi) fibres, (vii) dyes and tans, (viii) various others, such as tobacco, pyrethrum and sugar cane which do not fall naturally into groups.

Many examples of produce, both natural and after manufacture, can be easily obtained by a teacher who is alert, and a collection should be built up. It is worth noting here that they could do much to improve their teaching aids if they would co-operate with other teachers living in different surroundings. For example, by means of correspondence, a specimen of coconut fibre from a coastal area could be exchanged for a specimen of sisal or other fibre from an inland area; rocks from volcanic countryside could be exchanged for stones from an area where only sedimentary rocks are to be seen; seeds of typically highland plants might be passed on with a request for seeds from a lower altitude.

It would be valuable to include an outline of the process of raising a particular cash crop from the nursery stage to maturity, with definite reference to a local example which can be observed and

studied practically. Consider the steadily increasing value of the plantation in which it grows, and the immediate cash value of the produce itself when it reaches a condition of maximum growth and yields are greatest. Stress once again, however, that as the produce is to be sent away from the farm, fertility will be reduced in the soil, and this must be guarded against by the farmer.

Practical work

a. Make a more detailed study than hitherto of plants used locally as medicines. This should be based on locally acquired information. Examples of the relevant parts of the plants will be collected and, whenever possible, made into a display on the nature table. Include specimens of those plants used for chewing, such as the betel-nut and betel-leaf and the kola-nut. What is the value to the country of these medicinal and other plants?

b. Tea, coffee, cocoa and maté are the principal beverage crops grown in tropical lands. Write to the commercial companies concerned and obtain information and if near enough, permission to visit factories where the plant products are processed. At what altitude do the various crops thrive? What kind of soil conditions do they prefer? What varieties of each are there? Which are used most throughout the world? How are they used? Children in all countries should be familiar with the appearance of the plant, the leaf and the fruit of these important cash crops.

c. Acquire samples of oils by crushing various plant parts. As they are collected, put them in small bottles, neatly labelled, on the nature table. Experiment in the garden with the growing of well-known oil plants, such as castor, sunflower, coconut and the oil palm (*Elaeis*), choosing examples which suit the locality. Give a lesson on the so-called 'essential' oils, such as citronella, sandal-wood or clove oil. From what parts of these plants is the oil obtained? In what way does the oil differ from that obtained from the former kinds?

d. Make a collection of plants which yield dyes (e.g. *Indigofera*). What are such vegetable dyes used for? How are they extracted from the plant?

e. Continue to make use of local fibres in craft-work, now being somewhat more ambitious and constructing such objects as banana-leaf plant pots, sisal-fibre mats and baskets, coir or papyrus mats, etc. Try to obtain a specimen of a cotton 'boll'. Where are the seeds of this plant? What use is made of the seeds from an agricultural point of view?

f. Keep a constant look-out for other kinds of produce from plants, such as lumps of 'gum arabic' from *Acacia* trees; rubber, from various wild plants as well as the cultivated *Hevia*; and 'gutta-percha' from trees such as *Palaquium*.

(4) to (8): *Fodder crops for livestock*

As an introduction, remind the class that as farm animals improve in quality in tropical lands, they will only be able to give of their best if fed properly, particularly during the dry seasons of the year; and that this means growing food specially for them.

Show examples of common food plants used as fodder for livestock. Compare the food content of each. Classify them according to whether the food is valuable because of the starch it contains (grain crops, for example), the protein (lucerne, for example), or because of its moisture content (for example, some root crops, or melons).

Teach that grass should always be thought of as a crop, and revise the process of hay-making, comparing different methods. Describe how to assess good quality hay, and stress again its superiority to grass just left to dry in the fields. If there is any silage available locally to examine whilst out on a farm walk, refer to it as a method of preserving grass in a moist condition, which makes it often more palatable to livestock than hay.

Refer to concentrated foods (e.g. sunflower seeds), and show examples of manufactured foods (e.g. cattle cake). Describe the method of feeding cattle in the stall during milking time and of giving calves a meal ration (e.g. a mixture of bran, beans, and minerals). What are the advantages of paddocking as a means of feeding grass direct to livestock? What is the meaning of 'steaming-up'? How much hay will a cow eat in one day? How much water does a cow need to drink each day?

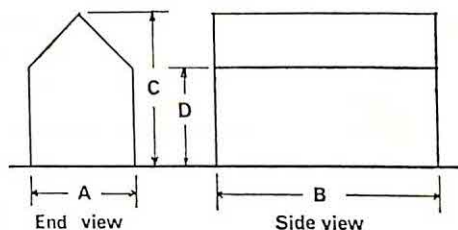
Practical work

a. A few selected examples of local fodder crops may be grown in the school garden as teaching material. These may be included in the garden rotation; or cultivated on separate plots, if required to remain in the ground for a number of seasons (e.g. lucerne).

b. Fodder plants vary in their contents and in their value as food for livestock. Pupils should be encouraged to observe such plants on nearby farms and to ask the farmers and agricultural officers questions related to these facts. For example, 'Why are particular plants more suited to one kind of livestock than another as fodder?',

and 'How much of each kind of fodder crop must be fed to each animal daily?'

c. Do some practical work related to hay-making if possible. Examine a good sample. Smell it; twist a fist-full in the hands and note whether or not it is quite dry; note whether it was cut when the grass plants were in flower or only at the leafy stage. Measure quantities. How much is twenty pounds in bulk? How much weight of hay is contained in a bale? Observe a hay-stack, if possible, and estimate its quantity.



VOLUME OF STACK =

$$A \times B \times D \text{ plus } \frac{1}{2} A \times B \times (C - D)$$

cubic measure

FIGURE 91. Calculating the volume of a stack

d. Let pupils observe, or see pictures, of particular kinds of farm machinery used for hay or silage making. If practicable, watch them at work. What is the source of power? Examples are grass-cutters, balers, rakes, and swathe-turners.

N.B. The above activities will only be possible if there is a modern, well-managed farm or institute of considerable size within reach of the school. If not, teachers must do all they can to acquire pictures from magazines and catalogues, of foodstuffs and equipment used for the growing of fodder crops. Visual aids are essential in this topic.

(9) to (12): Feeding farm animals

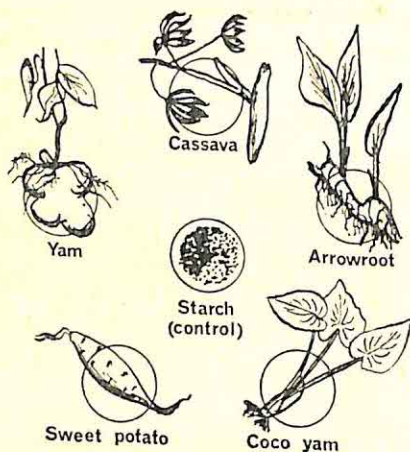
This subject is, of course, closely related to the previous one, and the main ideas will be brought out as a result of a farm visit as usual. The basic point to be understood is that animals need food, not only to keep themselves alive, but also to produce meat, milk, wool, and so on. A grazing cow, for example, if left to its own resources, will usually be able to find enough food for maintenance purposes, but will need a special ration of food for the production of milk, in the form of concentrated proteins and carbohydrates.

An adequate water supply is really an essential to successful farming, yet it remains a fact that many tropical farmers have to make do with a small ration obtained from a communally used stream, one a day at the most. Equally important is the fact that salt and other minerals are always needed by domesticated animals. Information may be obtained from local suppliers as to the variety of mineral licks and powders which are available. Samples may be obtained and their composition ascertained, as additional material for teaching. What are the values of such minerals to animals?

The meaning of 'chewing the cud' will already be understood and a diagram of the digestive system of ruminants will provide additional information. In what way does the digestive system of a pig differ from that of a cow or sheep? Where does digestion start? How do the sugar solution and other juices which are the end products of digestion pass into the animal's blood stream?

Practical work

a. Add iodine solution to various root crops, e.g. sweet potato, to ascertain which contains starch. If starch is present, the colour of the



TO SLICES CUT FROM EACH ROOT
ADD A SMALL QUANTITY OF
IODINE SOLUTION
OBSERVE WHICH TURN BLUE-BLACK
INDICATING STARCH

FIGURE 92. Testing root crops for starch

stain changes from amber to blue-black. Use a sample of pure starch as a control.

b. In the classroom, heat a small sample of maize meal in a glass tube

as an example of a carbohydrate concentrate. A gas will be seen to be given off which will turn lime-water milky proving that it is carbon dioxide. Drops of moisture will collect on the sides of the tube in which the maize is being heated; and this liquid will turn white copper sulphate blue again, indicating that it is water. (Figure 93.)

c. A small amount of sugar may be heated on a tin lid. There will be a characteristic smell of 'caramel' followed by charring, and formation of carbon. If a mirror, or other cool surface, is held over the sugar whilst it is being heated, moisture drops will condense on it; and this can be shown to be water, extracted from the sugar, as in (c).

d. To test for proteins in foods is not possible without special chemicals, but if some boiled white of egg, or a piece of meat, is put in a tin lid and heated, charring and a strong odour will be noted, which are typical of protein burning.

e. Take a small quantity of wheat flour (which contains more protein than most cereals) and wrap it in a piece of cloth. Holding it under water, work the flour with the fingers, squeezing the starch it contains out into the water. The residue in the cloth is the protein content of the flour. Try this with the flour from other cereals.

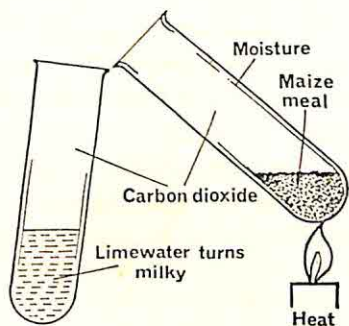


FIGURE 93. An experiment with starch

Assignment subjects

- (i) A detailed study of a selected cash crop.
- (ii) Local plants used as medicines.
- (iii) Methods of hay making.
- (iv) Rations for livestock.
- (v) Common fodder crops and their feeding values.

F. FARM ANIMALS

Main ideas to be brought out

- (1) Calves may be reared in a school compound; they need shelter, room for exercise, and protection from pests and diseases.
- (2) Calves, newly-born, need to drink the first milk from the cow; after that they need a regular supply of food and water.

- (3) Animals on farms may be seen to be sick by their appearance, temperature and pulse rate; or by taking a blood smear.
- (4) Good management is the best way of avoiding disease in livestock; animals must be kept in clean conditions and not overcrowded; sick ones should be isolated.
- (5) Livestock may need to be sprayed regularly against insect pests and dosed for worms.
- (6) Minor ailments, such as wounds, should be treated promptly to avoid further infection.
- (7) Many ailments of livestock will need the attention of a veterinary officer; the treatment may take the form of either prevention or cure.
- (8) Farm animals may be improved by breeding; animals closely related to each other, or those of different breeds may be mated together.
- (9) A pedigree is a registered line of descent; a pedigree animal is one which has such a record of breeding.
- (10) Careful breeding is useless if the land is over-stocked; therefore unwanted bull calves should be eaten or destroyed, and unwanted female calves should be sold.

(1) and (2): Calf rearing

Practical work

Although this activity will be mainly a lengthy outdoor occupation there are certain facts which need to be explained first in the form of lesson work. It should be explained that the first milk from a cow, the colostrum, has special value to newly born calves. It is believed to contain substances which help to protect the offspring from disease. It must then be taught that the calf should be fed properly thereafter. Build up a blackboard diagram or graph, showing a scale of feeding for calves to cover the first three months of its life. This will be based on a generous quantity of whole milk, as advised by the agricultural officer of the area. Compare it with feeding methods actually in use locally. Stress that the quality of a mature animal depends to a large extent on the manner in which the calf was reared.

It will not be possible for a school to keep a calf unless it can be provided for adequately, of course, and this will involve a certain amount of cash initially. The calf should only be kept for one term; at the end of that time, when it is about three months old, it should be sold. If this is not done, it will be likely to occupy too much of the time of the school staff and pupils, and the enterprise lose its educa-

tional value. The money obtained from its sale will go towards the purchase and keep of the next calf, during the following year.

For the routine tasks concerned with the animal's welfare, pupils are best grouped in pairs, and the various responsibilities changed round periodically, so as to give everyone in the class an experience of all the tasks involved.

Adequate provision must be made for the calf's accommodation before its arrival. Build a calf-pen and fenced-in enclosure, as shown. Use local materials as much as possible, and include provision for mangers or hay-racks. Give information about other needs of calves, such as the need for minerals and water to drink; and the value of dry, bulky food in preference to grass, at an early age. How is a calf taught to drink from a bucket?

Keep check on the health of the calf and give instruction from time to time on how to treat the common ailments as they may occur (e.g. ring-worm, scouring and infected eyes). Explain the purpose of castrating male calves, in order to get steers more suitable for fattening. What is the meaning and purpose of dehorning?

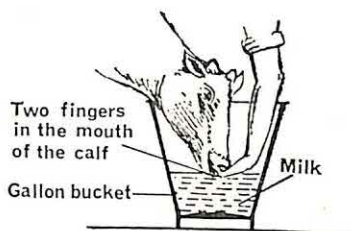


FIGURE 94. A method of teaching a calf to drink from a bucket

If a calf is cared-for in ways such as are suggested here, it will become tame and a real member of the school community, of interest to children at all stages. As usual, a livestock notebook should be kept up-to-date, by pupils entering in the records of the routine tasks as completed, and any observations they may have made of particular significance.

(3) to (7): *Animal health and hygiene*

Observations on farms may be made of the condition and health of livestock, and the general standard of hygiene maintained. The overall aim is to encourage pupils to develop an inquiring attitude to the possible sources of disease and infection, due to insanitary conditions around the farms, homes and villages. Where does the responsibility for clean surroundings lie? What can be done to bring about improvement?

Pupils' attention must be drawn to the state of animals seen along the roadsides (e.g. undernourished cattle, sheep and overworked donkeys). Are there signs of ill-health? What steps could be taken to

improve animal health? Are there too many animals of poor quality allowed to remain alive?

What are the causes of diseased livestock? Give examples of how disease may be caused by infected injuries, by adverse climatic conditions, or by air or water-borne germs. Refer to the possibility of inherited diseases; and emphasize the importance of obtaining new stock from disease-free farms, whenever possible.

How can minor ailments be treated? Consider sores, fractures, wounds, lameness, sprains, burns, and bites in this respect.

Discuss the necessary routine measures required on a farm against disease. Consider the need for 'worming' livestock periodically, and refer to the importance of spraying against ticks, and the diseases they convey. The general necessity for hygienic habits on a farm ought to be understood, including disposal of waste by alternative methods, such as composting, burning and burying. Pupils should have some idea of the probability of human infection if such measures are not taken on farms, as so much of the produce is used for human consumption.

A local veterinary officer may be asked to call at the school and talk to the pupils about his work. He will point out that he is concerned with prevention just as much as with cure. To prevent disease, he will encourage high standards of farm management, the use of strong and healthy breeding stock, proper feeding of animals; and for

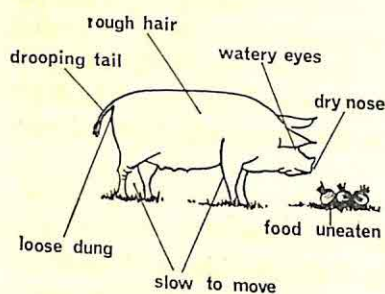


FIGURE 95. Symptoms of a sick animal

some cases, animals may also be injected with medicine, in the same way as with serum, using a hypodermic syringe.

Practical work

a. Using a live animal, or a large diagram, teach the symptoms of a sick animal, such as may be observed from its general appearance. Draw attention especially to its eyes, coat, mouth and general liveli-

ness, and to whether it is eating or not. The state of its dung and urine is another guide to an animal's condition. (Figure 95.)

b. Give instruction in the use of a thermometer. Teach the various normal temperatures of common domesticated animals, and how to take their temperature (e.g. by placing the thermometer in the anus of a cow).

c. Demonstrate how to check the pulse rate of animals (e.g. the pulse of a cow can be heard when the ear is pressed against its left flank). Demonstrate the correct place on the bodies of other animals to feel both skin temperature and pulse rates.

d. Teach how to take a blood-smear which can be sent to a veterinary laboratory for testing. Give the reasons for doing so, and name some of the diseases for which it would be necessary. What will the veterinary officer look for in the blood smear?

e. The spray-race for cattle, and the dip for sheep, may be seen on some farms. If a hand pump is in use nearby for the spraying of livestock, the mechanical principles involved may be referred to again. How is the spray made to come out under pressure?

f. Make observations of those insects which carry disease, together with other closely related animals such as the tick, and the mite which causes 'mange'. Observe the tsetse fly with the aid of a hand lens. How does it differ from the common house fly?

g. A school should have a small set of first-aid equipment for use on livestock. Make a box to keep it in. What would it be wise to include in this veterinary equipment?

(8) to (10): *Livestock improvement*

The breeding of domestic livestock is, in many respects, the most important of all agricultural activities. All people who live in a rural community should have an understanding of the principles used by breeders. The considerable differences to be seen between domesticated animals and the wild ones from which they have developed, are not always appreciated (e.g. compare a wild pig with a specimen of the Large White breed).

The question 'Why is livestock breeding important?' may be answered by explaining that one improved animal is likely to be worth more to a farmer in every way than a number of beasts of poor quality. The fundamental principles of bringing about improvement concern heredity; and at this stage of education, there is not the time to go into that topic in detail. Nevertheless, the idea that all offspring bear a likeness to their parents can easily be appreciated by

pupils, even whilst still at the primary school. It should be taught that livestock breeders use this fact to perpetuate characteristics in their stock which are desirable. Similarly, the fact that no offspring is exactly like its parent and always shows variation, ought to be understood. This is the means whereby a farmer can obtain young stock which are different from, and superior to, their parents.

Breeding begins with the selection of suitable females of good type, and the subsequent use of pure-bred males: it is in this respect that

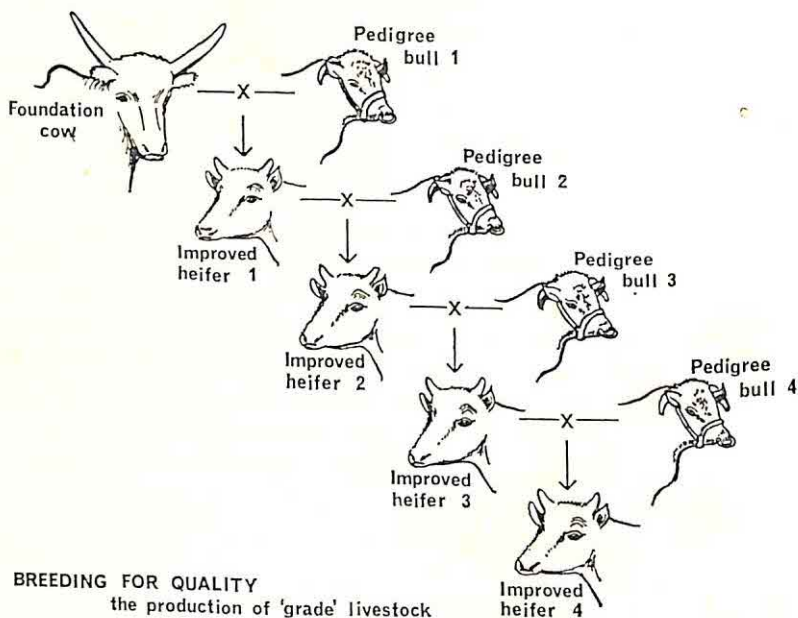


FIGURE 96. How to improve livestock through breeding

the idea of pedigree may be introduced. Refer to the breed societies and the herd books they keep. Find out if there is a local breed society of any kind in the country. The realization that a bull is likely to become the sire of the whole herd explains its importance in breeding.

Further information about breeding may be given by defining such terms as 'line-breeding' (the mating of animals closely related to each other), and 'cross-breeding' (the mating of animals of different breeds). The idea of hybrid vigour can be most easily taught in connexion with cross-bred poultry: such birds are usually healthier, come into lay earlier, lay more eggs, etc., than birds of pure stock.

The meaning of 'grade stock' is best taught when dealing with

cattle. In many tropical countries, pure-bred bulls of European breeds have been introduced in order to improve the indigenous stock, and many grade animals are to be seen. What is the difference between pedigree stock and grade stock? (Figure 96.)

Of overall importance to a farmer who is trying to improve the quality of his stock is the necessity of not keeping too many animals on the farm land. Teach the need for the control of stock numbers, if high quality is to be maintained. If animals are being kept alive through improved veterinary aid, as is the case in many areas, then a corresponding control of new births is essential if the land is not to become overstocked, as the amount of land which is available for livestock everywhere is strictly limited in extent. What methods are appropriate to bring about this control?

Practical work

a. There may be the opportunity in some areas for schools to be visited by the veterinary officer concerned with artificial insemination of cattle. The widespread success of this technique of breeding by bringing about rapid improvement in the herds of cattle owned by farmers unable to afford to keep their own bull, should be stressed, and any prejudice overcome. Why do long distances between farms and A.I. centres, and poor road conditions, make it difficult to use A.I. effectively? Why is A.I. particularly useful to a small farmer?

b. One objective of a visit to a farm should be to estimate the value of the livestock by observation. Give pupils practice in grading

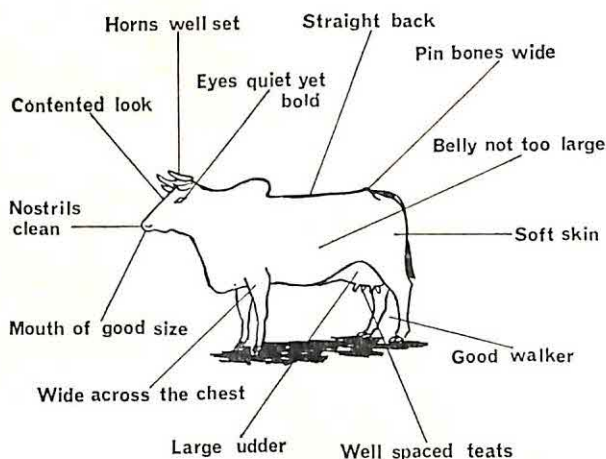


FIGURE 97. Some points of good quality cattle

animals of different quality, and teach the external 'points' of the various breeds.

c. Demonstrate how livestock can be 'tested' by estimating the egg-laying capacity of a hen. Obtain records from a farm of the number of eggs laid by a bird over a known period of time. Calculate the expected annual rate of egg production. Point out that the performance of an animal reflects the quality of the parents. Teach that breeders test their animals for pedigree, performance and appearance; and refer again to the records kept by breed societies.

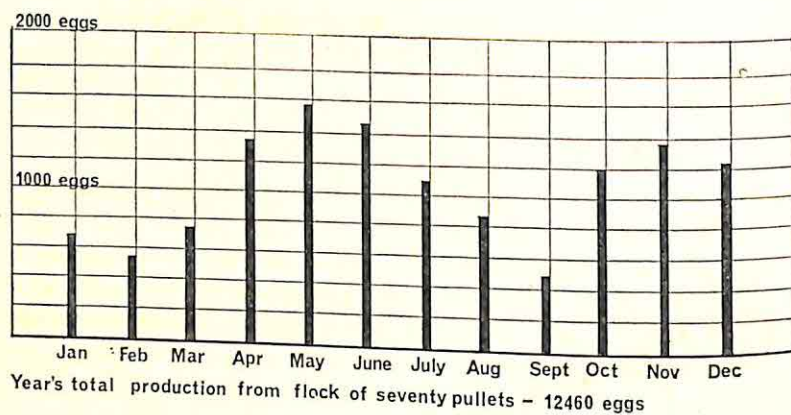


FIGURE 98. Recording egg production

d. It will not be possible for pupils in schools to take an active part in the improvement of livestock; but if pets are kept, they may be allowed to breed, and thus some experience of the topic obtained. What inherited characteristics can be seen in the offspring? Is likeness more accentuated than variation?

Assignment subjects

- (i) Rations for calves.
- (ii) First-aid for farm animals.
- (iii) The work of the veterinary officer.
- (iv) Points of selected farm stock.
- (v) Methods used by livestock breeders.

APPENDIX 1

Some Definitions

AFTER-BIRTH: membrane which envelops the offspring in the womb before birth, and which is afterwards discarded.

AILMENT: sickness.

ALCOHOL: liquid chemical produced during fermentation.

ALLUVIUM: earthy deposit of surface water.

ANNUAL: recurring yearly; plant living for one season only.

ANTI-BODY: substance in the blood which counteracts the effects of minute organisms which would otherwise harm the body.

ASPECT: direction in which a building or plot of land is facing.

BACTERIA: name of a group of minute living organisms found almost everywhere.

BALE: bundle of hay made by a machine for storage purposes.

BEEF: flesh of an ox; meat obtained from cattle in general.

BEVERAGE: a drink made from plant produce, such as tea leaves.

BLOOM: fully open flower.

BOUGH: a branch of a woody plant.

BOUNDARY: dividing line; an encircling demarcation.

BRASSICA: kind of green-leaved vegetable plant. Botanical name of a group of flowering plants, all of which have four-petalled flowers appearing generally after the second season's growth.

BRISTLE: a short stiff hair, generally on the backs of animals.

BUD: a flower not yet open.

BULB: a food-storage organ of certain plants in which the leaf base is swollen at ground level.

BULLOCK: immature male of cattle; steer.

CALF: young cattle of either sex.

CAPON: castrated male bird particularly of fowls.

CARBOHYDRATE: a group of food substances, compound of carbon and water.

CARPEL: female part of a flower which contains the seeds.

CASTRATION: process of making a male animal unable to reproduce by removal or destruction of the testicles.

CEREAL: edible grain; type of grass whose seeds are used as food.

CHAFF: papery outer covering of a grain.

COCKEREL: young male of fowls.

COLOSTRUM: the first rich milk from a female mammal immediately after giving birth.

- CONCENTRATE: to collect at one point; foodstuff for livestock containing much protein or starch in proportion to the total mass.
- CONIFER: a tree, bearing cones (seeds not contained in an ovary).
- CONSERVATION: preventing loss, change or destruction.
- CONSOLIDATION: combining together; particularly of areas of land into one self-contained unit.
- CONTAMINATION: infecting or polluting.
- CONTOUR: imaginary line joining points at equal heights above sea level; enabling an estimate of altitude.
- CO-OPERATION: making a joint effort; working together.
- CORM: a food-storage organ of certain plants in which the stem is swollen at the base.
- COTYLEDON: seed-leaves of a plant; sometimes remaining within the seed-case.
- COULTER: metal, disc-shaped part of a plough, fixed vertically in front of the plough-share, in order to cut a clean edge to the furrow.
- CUD: partially digested food of a ruminant.
- CULINARY: of or for cooking.
- CULLING: process of eliminating poor specimens of livestock.
- DAIRY: building in which milk is weighed, cooled, etc.
- DAM: female parent; an artificial lake.
- DECAY: rot, decompose, decline in quality.
- DECIDUOUS: the annual shedding of leaves by a tree.
- DENSITY: mass of matter contained in a unit volume.
- DEW: air vapour condensing on cool surfaces in small drops at night.
- DIFFUSION: spreading around; affect of mixing a concentrated solution with a weak one.
- DILUTION: making a solution weaker.
- DOMESTIC: of the home; kept by man (of animals).
- DOMINANT: prevailing; over-riding; supreme.
- DRAKE: male duck.
- DROUGHT: continuous dry weather.
- DUCKLING: young duck or drake.
- DUNG: excrement of animals.
- EARTHENWARE: baked clay, used for making vessels.
- ECONOMICS: material and monetary welfare of a country.
- EDIBLE: fit to be eaten.
- ELEMENT: component part of matter; the molecule of which contains atoms all of the same kind.
- ENCLOSURE: a closed-in area of land.
- ENERGY: force; ability; vigour; the ability to do work.
- ENGINE: machine to convert energy from one form to another.
- ENVIRONMENT: surrounding objects.

- EQUILIBRIUM: effect of two equal forces acting in opposite directions.
- ERADICATE: root out; get rid of.
- EROSION: wearing away.
- EVAPORATION: to give off moisture; process of a liquid changing to a gas.
- EWE: an adult female sheep.
- FALLOW: ground left uncultivated for a season or more.
- FARROW: giving birth to a litter of pigs.
- FERMENTATION: breaking down of sugar into simpler substances by a living organism such as yeast.
- FERTILITY: term commonly used to refer to the potential of the soil as regards crop production. In respect of livestock, means the ability to bear offspring.
- FERTILIZATION: making fertile (e.g. by pollination).
- FERTILIZER: substance used to make the ground productive.
- FIBRE: strong thread-like substance, generally of vegetable matter.
- FLEECE: woolly covering of a sheep's skin.
- FLORET: small flower; often found in clusters; common on grasses.
- FODDER: food for livestock.
- FORCE: effect needed to move an object from a state of rest.
- FREEZING: becoming rigid; change of state from liquid to solid.
- FRICTION: resistance to movement of one body in contact with another.
- FROND: leafy part of a fern plant.
- FUEL: material for making fire or for burning; source of power in engines.
- FUNGICIDE: chemical substance poisonous to fungus plants.
- FUNGUS: a type of spore-bearing, non-flowering plant, without green colouring matter.
- FURROW: a narrow trench made in the soil.
- FUSION: melting or joining together.
- GANDER: adult male of geese.
- GERMINATION: sprouting; causing to form shoots.
- GESTATION: period of time whilst the young is carried in the womb after conception and before birth.
- GILT: young female pig, before bearing offspring.
- GNAWING: biting persistently, particularly with the incisor teeth.
- GOSLING: young of geese, either sex.
- GOSSAMER: filmy substance of small spiders' webs.
- GRADE STOCK: cattle which are the result of a cross between pedigree bulls and non-pedigree cows or heifers.
- GRAIN: fruit of a cereal plant.
- GRAPHIC: of drawing; vividly descriptive.

- GRAVITATION: attraction between all particles of matter in the universe; particularly between the earth and objects on its surface.
- GRAZE: feeding on growing grass in a pasture.
- GULLY: a water-worn groove across country, due to erosion.
- HABITAT: natural home of plants or animals.
- HARROW: frame with iron teeth for breaking lumps of soil, drawn by a tractor.
- HARVEST: process of reaping and gathering, particularly of grain.
- HAULM: stalks of grass, beans or other plants.
- HEIFER: young female of cattle.
- HERB: plant with a soft stem; plant used as medicine, etc.
- HERD: a number of cattle feeding or living together.
- HEREDITY: transmission of characteristics from one generation to another.
- HOE: tool used for loosening the soil surface.
- HOG: castrated male pig; young sheep before shearing.
- HOMOGENEOUS: of uniform composition throughout.
- HUMIDITY: dampness of the atmosphere.
- HUMUS: vegetable mould, decomposed plant material.
- HUSBANDRY: agricultural management and care of the land.
- HYBRID: cross between two different species of plant or animal.
- HYPODERMIC: introduced under the skin.
- HYPOTHESIS: theory or idea put forward in explanation of the facts.
- IMMUNITY: freedom from infection or disease.
- IMPERVIOUS: not allowing the passage of fluids through its substance (impermeable).
- INCUBATION: hatching by sitting on eggs.
- INDIGENOUS: native; belonging naturally.
- INFECTION: communicating disease, especially by air or water.
- INOCULATION: implanting medicine or vaccine into a body to prevent disease.
- INSEMINATION: process of implanting semen into the body of a female mammal.
- IRRIGATION: to supply the land with water artificially.
- ISOLATION: keeping apart or alone.
- JUICE: liquid part of a fruit or vegetable.
- KID: young goat of either sex.
- LACTATION: period of time that a female mammal is producing milk.
- LAMB: young sheep of either sex.
- LARVA: intermediate stage in the life-cycle of an insect, which follows the egg stage.
- LAVA: rock material flowing in a hot molten state from an erupting volcano.
- LAWN: an area of mown grass in a garden.
- LEGUME: fruit formed from a single carpel which when dry sheds

- its seeds. Term used to refer to a group of flowering plants all of which have dry fruits of this particular kind (cf. pulse crops).
- LEY: a field of temporary grass remaining in the ground for a number of seasons.
- LIGHTNING: flash of light due to electricity passing from cloud to cloud, or from cloud to earth.
- LOAM: rich soil containing well-balanced proportions of sand, silt and clay particles and adequate humus.
- MACHINE: apparatus to make work easier and more efficient; the action of its parts combines to apply a mechanical force to the task in hand.
- MANGER: a container for holding food for livestock.
- MANUAL: with the hands.
- MANURE: dung, or other substance, used for fertilizing the soil.
- MARSH: area of low-lying wet ground.
- MASS: quantity of matter in an object.
- MATURE: fully developed.
- MEAN: the average.
- MECHANIZATION: process of causing an activity to rely on machine power, in place of manual labour.
- MEDICINE: a drug or potion used to heal sickness.
- MELTING: change of state from solid to liquid.
- METAMORPHOSIS: change of form (particularly of insects or amphibians).
- MICROSCOPE: instrument used to see objects not visible with the naked eye; consists of an arrangement of lenses.
- MINERAL: substance not animal or vegetable; chemical compound obtained from the earth.
- MOISTURE: liquid in the form of small diffused drops.
- MOULD: fungus with a woolly appearance, formed on moist surfaces or organic substances.
- MULCH: material, such as vegetable matter, placed around plant roots in order to conserve moisture in the soil.
- NECTAR: sweet fluid yielded by certain plants, in the flower.
- NOCTURNAL: active by night.
- NODE: knob or swelling on root or branch of plants, particularly on grasses.
- NUT: fruit consisting of a hard shell enclosing an edible content (the kernel).
- NUTRIMENT: nourishing food.
- ORCHARD: plantation of fruit trees.
- ORGANISM: individual animal or plant.
- PARTICLE: minute portion of matter.
- PASTURE: herbage as food for livestock as it grows.
- PALATABLE: agreeable to taste.

PAPAIN: the milky juice obtained from the skin of the pawpaw fruit.

PEDIGREE: a recorded ancestry or line of descent.

PENDULOUS: suspended; hanging; drooping.

PERENNATING: making everlasting.

PERENNIAL: everlasting (particularly of a plant); lasting more than one or two seasons.

PERMEABLE: allowing the passage of fluids; pervious.

PEST: animal or plant troublesome to man.

PETAL: leaf-like part of a flower, generally coloured.

PHENOMENON: an observed happening or object.

PIGLET: young pig of either sex.

PLANTATION: large number of trees or plants of the same kind grown together on one estate.

PLIABLE: easily moulded; yielding.

POISON: substance, that when taken in by a living thing, kills or injures it.

POROUS: having pores, therefore permeable.

POWER: work done in a certain unit of time.

PREDATOR: killer of living prey.

PROPAGATION: increasing by artificial methods, referring to plants.

PROTEIN: a group of organic compounds containing carbon, water and nitrogen mainly; an important food substance.

PRUNING: cutting off dead branches or other unwanted part of a plant.

PULLET: young female of fowls.

PULSE: edible seeds of leguminous plants; (in animals) a throbbing of the arteries due to the heart beat.

PUNGENT: strong; stinging; biting (of flavour or smell).

RAM: adult male sheep.

RANCH: large cattle farm on grassland.

RATION: fixed allowance of food.

RESERVOIR: an artificial pool or lake for water storage.

RESIN: sticky substance given out by certain plants, notably conifers.

RHIZOME: special kind of underground stem of plants.

RIGIDITY: state of being unable to bend.

RUMINANT: animal that chews the cud.

SAP: the juice of plants.

SATURATION: filled with moisture; having absorbed the maximum amount of another substance.

SCENT: fragrance; characteristic odour or smell.

SEDGE: a grass-like plant growing in wet places.

SEEDLING: young plant raised from a seed.

SEPAL: leaf-like part enclosing and protecting the bud of a flower.

SERUM: watery animal fluid obtained from blood.

- SHEARING: cutting off the fleece of a sheep.
- SHEARLING: name given to a young sheep over sixteen months old.
- SIRE: male parent.
- SOLUTION: mixture of two or more substances forming a uniform mass.
- SOW: adult female pig.
- SPECIES: a group of living things which have close similarities and numerous common properties.
- SPECIMEN: individual from which the properties of the kind may be recognized.
- SPICE: aromatic or pungent vegetable matter used for flavouring.
- SPORE: a reproductive cell of certain plants which can give rise to a new plant without needing to be fertilized.
- STAMEN: part of the flower which produces pollen.
- STATISTICS: numerical treatment of facts.
- STEAMING-UP: the process of giving extra food to dairy cows during the weeks immediately before calving.
- STEER: see BULLOCK.
- STIGMA: part of the flower which receives the pollen.
- SUBSISTENCE: adequate to exist on.
- SUCKER: new shoot or stem of a plant thrusting up from the roots.
- SUSPENSION: particles of one substance supported in another.
- SWARD: expanse of grass and other plants growing together in a pasture.
- SYMPTOM: a sign of illness.
- SYNTHESIS: putting together.
- TAP-ROOT: long root of a plant thrusting vertically down into the soil.
- TECHNIQUE: method of action; manner of completing a task.
- TEMPERATURE: measurement of an object's heat.
- TENDRIL: thread-like shoot of a plant used for clinging or climbing.
- TETHER: the rope by which a grazing animal is restricted to a certain area.
- TEXTURE: degree of openness or closeness in the surface of a substance as experienced through touch.
- THUNDER: noise made by lightning.
- TILLAGE: preparation of the land for crop-bearing.
- TILTH: finely cultivated surface soil.
- TRACE ELEMENTS: certain chemical elements found in minute quantities in the soil which are essential ingredients of the substance of living things.
- TRANSPIRATION: passage of moisture outwards through pores in the surface layer of a leaf or other plant part.
- TUBER: swelling on the roots of some plant parts capable of putting forth buds.

TURF: clump of grass with soil attached to the roots.

TURGID: (of plants) swollen with sap.

UMBEL: flower-head in which many flower stems all spring from one point at the top of the main stem.

VACCINE: preparation made from the organisms forming a disease, which is inoculated into a body to help build up its own resistance.

VERMIN: name given to creatures harmful to man, crops, etc.

VIRUS: minute organism showing many characteristics of living things which is the cause of disease in plants and animals.

VOLUME: amount of space occupied by matter.

WEED: wild plant found growing where not wanted or planted.

WEIGHT: quantitative measurement of gravity as a property of matter.

WETHER: castrated ram.

WILTING: effect observed when the cells of a plant leaf or stem are drained of sap.

WINNOWING: separation of the chaff from the grain by the use of wind.

WITHER: to become dry or shrivelled up.

WORK: measurement of the force required to move an object from rest, multiplied by the distance moved.

APPENDIX 2

Equipment for Rural Science Teaching

ITEMS FOR LESSON WORK

Drawing paper	Cotton wool
Manilla card	Pencils and crayons
Fibre board	Indian ink
Straw board	Red ink
Blotting paper	Record books
Pieces of cloth	Balance and weights
Modelling clay	Stove and fuel
Sawdust	Graduated measuring jug
Used tins and lids	30 ft glass tubing (5 mm)
Glass jars and bottles	Test tubes and bungs with holes (6 doz.)
Corks	Filter papers
Used kerosine tins	12 funnels (plastic, glass or metal)
Pieces of mosquito netting	20 ft rubber tubing (5 mm)
Pieces of wood	6 thermometers (Centigrade and Fahrenheit, and Maximum and Minimum)
Plywood	Plaster of Paris
Miscellaneous wheels, cogs, etc.	Common salt
Strips of metal	Sugar
Lengths of copper and iron wire	Starch
Fencing wire	Vinegar
Pieces of glass	Lime water
Adhesive tape	Iodine solution
Glue	Epsom salts
Paste	Blue-stone (copper sulphate)
Dust pan and brush	Gypsum
Hand lenses (1 for each pair of pupils)	Baker's yeast
Earthenware plant pots	
Sticky labels	
Cotton thread	
Twine	

Collections of

Pressed grasses
 Weeds and other wild flowers
 Leaves and seeds
 Barks and woods of trees
 Insects
 Other plant parts
 Parts of animals
 Natural minerals, rocks, etc.
 Soils
 Plant products, fibres, oils, etc.
 Animal products, leather, etc.
 Insecticides, sprays, etc.
 Fertilizers
 Manufactured foods for livestock
 Seed packets
 Seedsmen's catalogues
 Implement manufacturers' adverts.
 Farming magazines
 Film strips, etc.

Pictures of

Domesticated animals
 Breeds of farm livestock
 Farming systems
 Farm buildings
 Farm equipment and machinery
 Soil erosion
 Terraces, dams, reservoirs, etc.
 Forests, trees, etc.
 World vegetation regions
 Deserts, polar and alpine regions
 Weather conditions

TOOLS FOR MANUAL WORK

- | | |
|---------------------------|-------------------------------|
| 1 Axe | 2 Brooms |
| Wedges | 3 Hammers |
| 2 Watering cans (2 galls) | 3 lbs Nails (varied sizes) |
| 2 Buckets (2 galls) | Staples |
| Dibbers | 3 gross Screws (varied sizes) |
| 10 Digging forks | 3 Screwdrivers |
| 10 Spades | 1 Mallet |
| 2 Shovels | 4 Chisels |
| 1 Large mallet | 2 Saws (one a tenon saw) |
| 10 Rakes | 1 pr Pincers or pliers |
| 10 Draw hoes | 1 Hand plane |
| 5 Push hoes | 1 Hand-drill and bits |
| 4 Secateurs | 2 Files |
| 1 Pruning saw | 2 Rasps |
| 10 Trowels | 1 Oilstone and oil |
| 10 Matchets or cutlasses | 1 Tape measure |
| Metal plant labels | 2 Metal rules |
| 1 Wheelbarrow | Glue |
| 1 Sieve $\frac{1}{4}$ " | |

APPENDIX 3

Book List

Many of the books that were listed in Volume I are still available and useful. There remains a shortage of books which deal with farming and gardening processes in particular localities, and of books suitable for the identification of plants in tropical areas, written in a manner that is appropriate for school use.

BOOKS ON GARDENING, AGRICULTURE AND RURAL SCIENCE

- Gardening in the tropics* Greensill (Evans)
- Handbook for rural science teachers in tropical areas* Greensill (Evans)
- Rural science for tropical schools* Greensill (Evans)
- Tropical library series *Farming; friends and enemies in the garden; garden series; things we use; geography series* (Longmans)
- An agricultural notebook* Paterson (Longmans)
- Rural Science course* Shorney (Nelson)
- School Gardening and Agriculture* Shanks (Oxford University Press, Nairobi)

BOOKS ON BIOLOGY AND NATURE STUDY

- Tropical Nature Study* Stone (Cambridge University Press)
- Elementary Botany for West Africa* Walters (Allen & Unwin)
- Biology and Hygiene for Tropical Schools* Nielsen (Evans)
- Nature Study for Africa* Thistleton (Evans)
- Nature Study in Malaya* Atkinson & Abu Hassan Bin Haji Ali (Longmans)
- Life and Living* Chaplin (Longmans)
- Botanical notes and drawings for West Africa* English (Oxford University Press)
- Simple experiments with insects* Kalmus (Heinemann)
- Simple experiments in Biology* Bibby (Heinemann)
- Natural History Series* Haworth (University of London Press)
- Biology for East Africa* Hadman (Oxford University Press, Nairobi)
- Nature Study for Africa* Thistleton (Evans)

BOOKS ON RECOGNITION OF SPECIES

- Animal life in the tropics* Walters (Allen & Unwin)
- Animals as friends and how to keep them* Shaw & Fisher (Dent)
- Tropical wild flowers* Graham (Hulton)
- West African nature handbooks* various authors (Longmans)
- Field handbooks series* various authors (Longmans)
- Malayan animal life* Tweedie & Harrison (Longmans)

- Useful animals of the world* Brimble & Edwards (Macmillan)
Animals in schools Volrath (Murray)
Common flowering plants of Uganda Lind & Tallantyre (Oxford University Press)
Plant life in West Africa Lawson (Oxford University Press)
Woody Plants of Ghana Irvine (Oxford University Press)
Wild flowers of the Ceylon Hills Bond (Oxford University Press)
A field guide to the birds of East & Central Africa Williams (Collins)
Highway Nature Guides to East Africa various authors (Longmans)

BOOKS ON GENERAL SCIENCE

- Finding out in science* Haggis & Hall (Cambridge University Press)
Elementary General and Soil science Thistleton (Allen & Unwin)
Learning science Nunn (Ginn)
Science education for the elementary school teacher Tannheim (Ginn, N.Y.)
Primary Science series Lauwerys (Harrap)
A course in Junior science Creaser (Longmans)
Everyday science for the tropics Godman & Hobson (Longmans)
Science in the school garden Johnstone (Macmillan)
Science for today Ferguson (Macmillan)
Book of experiments (3 vols) De Vries (Murray)
Simple Science and Nature Study Shanks (Oxford University Press, Nairobi)
Science in the Primary School ATCDE (Murray)
Approach to science in the primary school NEF (E.S.A.)
Science in early childhood (Columbia N.Y.)
La joie de connaître (série) Bourelleir (Colin, France)
Science d'observation Lazerges (Colin, France)
Elements de science physiques et naturelles Touraine (Istra, France)
The real book of science experiments Leeming (Dobson)
Introduction to natural science in primary schools (UNESCO, Paris)

BOOKS FOR GENERAL REFERENCE

- The science of living things* Palmer (Allen & Unwin)
Secondary Science for tropical schools Pheasant & Clarke (Allen & Unwin)
A new tropical hygiene Godwin & Duggan (Allen & Unwin)
Your body and how it works Cullis (Allen & Unwin)
Farm management in West Africa Phillips (Longmans)
Science in Agriculture Paterson (Longmans)
Health science for the tropics Godman (Longmans)
Source book for geography UNESCO (Longmans)
Handbook for science teachers in secondary modern schools Nunn (Murray)

- Introduction to tropical grassland husbandry* McIlroy (Oxford University Press)
Textbook of West African Agriculture Irvine (Oxford University Press)
Handbook of tropical agriculture Masfield (Oxford University Press)
Between us and Hunger Mayadas (Oxford University Press)
Insects and Diseases Edney (Oxford University Press)
Source book for Science teaching UNESCO (Oxford University Press)
The Place of Science in Primary Education. Edited by W. H. Perkins
(British Association for the Advancement of Science)

National Froebel Foundation Pamphlets:

- Active methods of learning* Langdon
Early scientific trends in children Isaacs
Activity and experience in Junior School Walters
From seed to seed Hutchinson
Scientific interests in the primary school Allen, Brown, Southam
& Tune
Children learning through scientific interests

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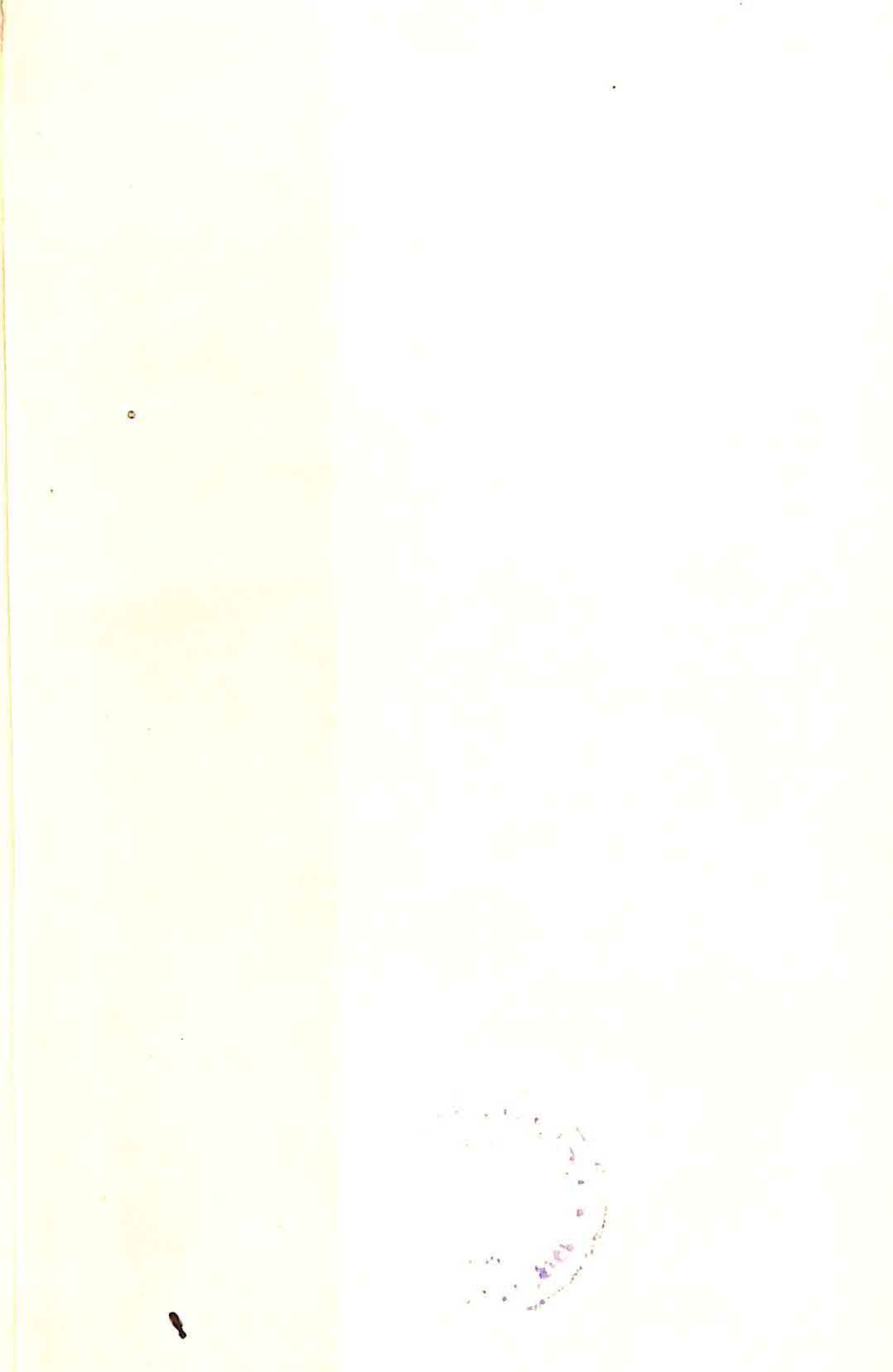
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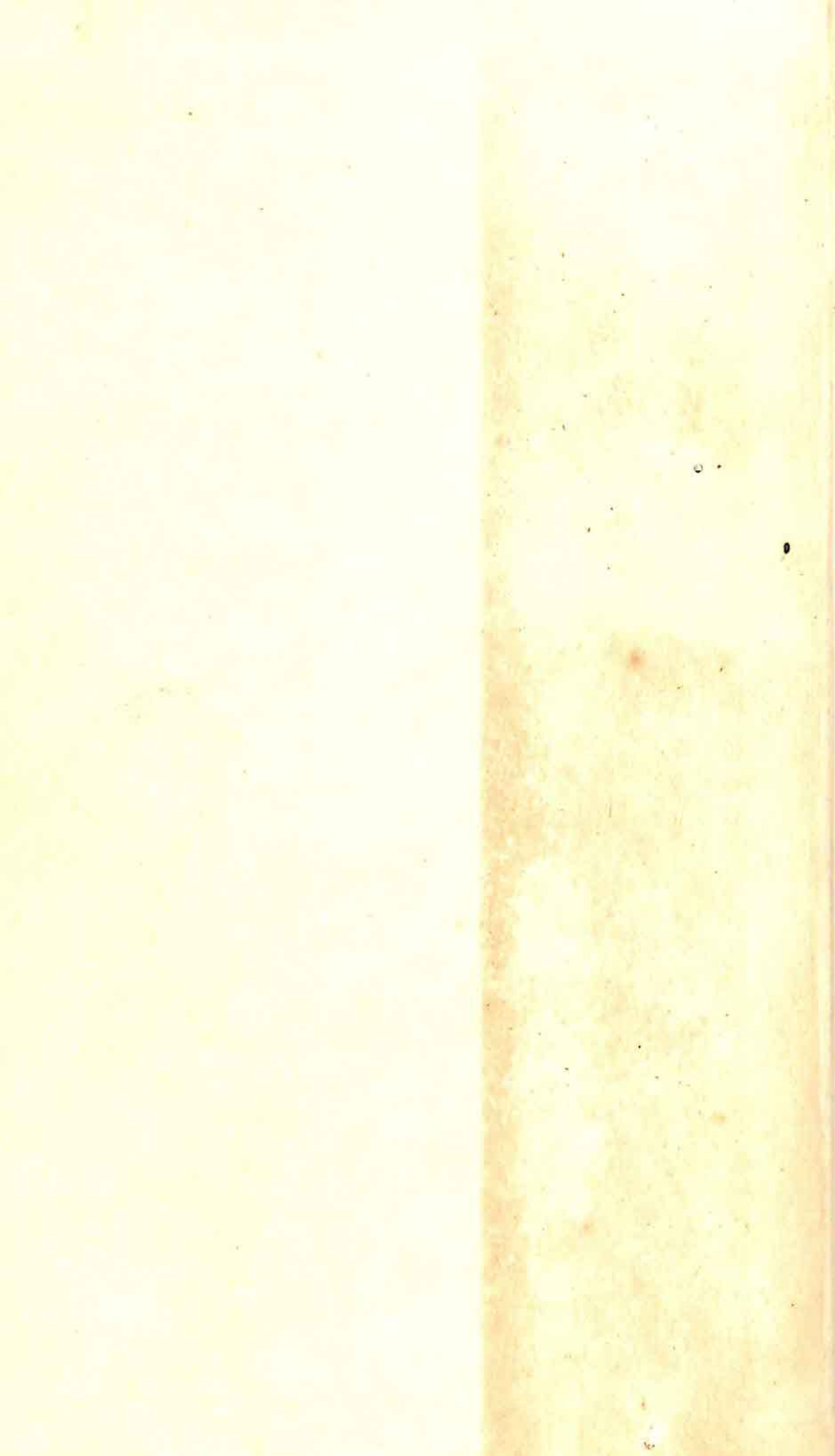
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